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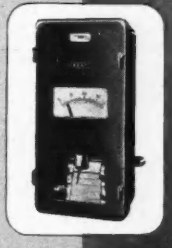

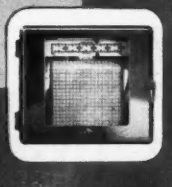

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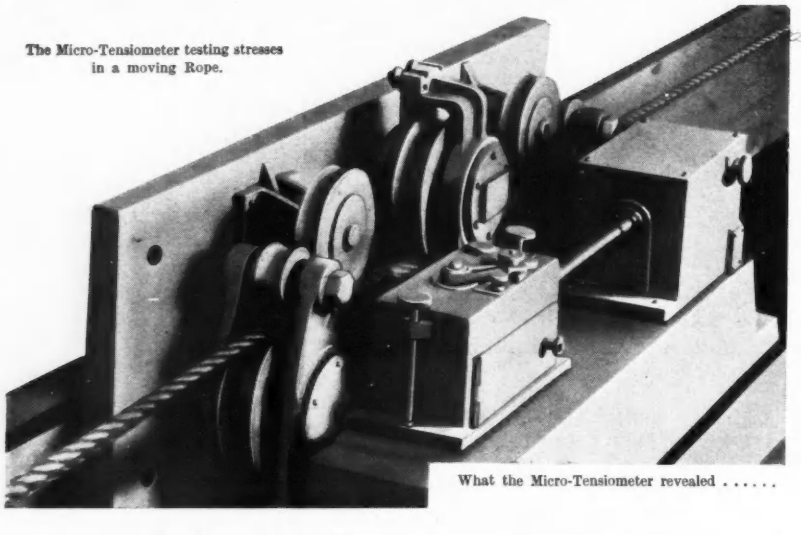
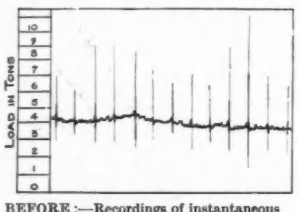
Top: the R.T.E.
Below: the Multelec

E/4910 G

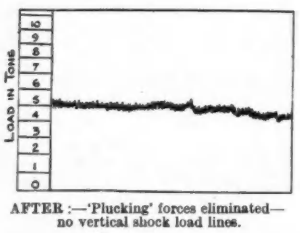
The Micro-Tensiometer testing stresses in a moving Rope.



What the Micro-Tensiometer revealed .....



BEFORE :—Recordings of instantaneous shock loading (vertical lines) due to 'plucking' on the surge, or Clifton Wheel.



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A Seven-Day Journal

The Joint Iron Council Dinner

THE fifth convention of the Joint Iron Council was held in London last week and concluded with a dinner on Thursday, September 21st, at which the Viscount Bruce of Melbourne was the principal guest. In the course of a speech proposing the toast of "The Council," Lord Bruce said that he had read both the Council's annual report and the report of the Grey Ironfounders' Productivity Team with considerable interest. From the report he had arrived at three important conclusions. First, co-operation was essential within an industry itself if it was to be successful commercially and nationally. Secondly, both efficiency and output must be increased—and the speaker added that the prompt action taken in connection with the Productivity Team's report showed that the ironfounding industry took this matter seriously. In making his third point, which he discussed at some length, Lord Bruce stressed the necessity for individual industries to have policies which were integrated with national wellbeing irrespective of political feelings. In deprecating the action of the Government in nationalising iron and steel, Lord Bruce pointed out that that industry had already introduced effective machinery for settling its problems, and Government interference was not only needless but dangerous to the wellbeing of the industry. After the president of the Council, Mr. F. Scopes, had thanked Lord Bruce, the health of the Anglo-American Council on Productivity was proposed by Mr. S. H. Russell, the leader of the Grey Ironfounders' Productivity Team. Mr. Russell told of the great co-operation and assistance the team had been given by industrialists and workers in carrying out its work in the United States and expressed the thanks of all concerned to Mr. H. P. Good, the president of the Gray Ironfounders' Society of the United States. Sir Frederick Bain, the following speaker, said that the success achieved by the team showed the goodwill which existed between men and management on both sides of the Atlantic when working for the common good of industry and when politics were eliminated. Mr. Good, in thanking the council for its hospitality, spoke of the freemasonry which existed amongst foundrymen and said how pleased his society had been to assist the team in its work.

Sewage Disposal Works of the L.C.C.

BOTH the London County Council, which is responsible for ensuring the purity of the effluent from London's main drainage system, and the Port of London Authority, which has control over all trade and other sewage effluents into the River Thames, are impressed with the importance of all possible safeguards being taken against river pollution. The L.C.C. recently constituted a Rivers and Drainage Committee for administration of its duties as the main drainage authority for the County of London, and has in hand important schemes at its northern and southern outfall works at Beckton and Crossness (see THE ENGINEER, January 6, 1950, page 31). On September 20th, the Minister of Health visited the site of the northern outfall works, where a contract valued at £850,000 for the construction of sixteen sedimentation tanks has just been let to Edmund Nuttall, Sons and Co. (London), Ltd. Further contracts associated with this project will bring the total cost to over £1 million. This work, together with a £250,000 project begun in 1939 and held up by the war, comprises the first instalment of the programme approved by the Council in 1947, which envisaged expenditure of nearly £3 million over a period of five years, on extensions to purification plant at the two outfall works, which deal with all the sewage from London and a number of adjacent out-county areas—a total area of about 180 square miles, with a population of some 4,500,000. The new sedimentation tanks will be mechanically operated and will work in conjunction with diffused-air activated sludge plant.

Standard Locomotives for British Railways

ACCORDING to an announcement of the Railway Executive, the first standard locomotives for British Railways will go into production this autumn, and will be placed in service early next year. About one hundred and sixty of the new standard engines will be built during 1951 and their construction will be shared between the works at Crewe, Derby, Swindon and Brighton—other works will continue the building and repair of previous types of locomotives. Six of the expected twelve new standard types will be represented in the 1951 programme and all are being designed for mixed traffic purposes in order to give the maximum inter-availability of use within their power range. The two bigger designs of the 4–6–2 type will be available for both express passenger or fast freight trains. These engines, it is stated, are designed to be capable of undertaking the duties and working over all routes now used by such types as the "Castles," "West Country," L.M.R. Class "6's," and ex-L.N.E.R. "V.2's." Standard 4–6–2 locomotives are designed to cover the duties of such engines as the W.R. "County" and L.M.R. Class "5X," and the heavier duties now being performed by the L.M.R. Class "5" and ex-L.N.E.R. "B1" class. Two other standard tender class locomotives to be introduced will comprise a mixed traffic 4–6–0 and a lightweight 4–6–0. The latter engine will have a greater range of availability and full modern equipment to replace numerous classes of 4–4–0 locomotives now becoming obsolescent. Each of these four mixed traffic tender-type engines will have a greater range of use for comparable traffic than the present types to which it is related. A new standard 2–6–4 tank engine will be used for suburban passenger and similar duties and a new 2–6–2 tank engine is intended for light passenger, freight and shunting work. In the design of the new standard locomotives all features calculated to increase mileage between repairs are being embodied to give maximum economy in operation consistent with an adequate reserve of power for traffic requirements.

Forage Harvesting Machinery Demonstration

ON Monday last, the Royal Agricultural Society concluded the field trials for the forage harvesting machinery competition which it has organised this year, and on the following day the twenty-seven machines entered for the competition were publicly demonstrated, under working conditions, at Shillingford, Oxon. The aim of the competition was to encourage the development and manufacture in the United Kingdom of machines for the handling and harvesting of forage, and entries were invited for three classes. The first, Class A, was for machines, already in production, for dealing with hay and straw from the windrow; Class B was for machines, in production, for handling green crops, while Class C was for prototypes dealing with hay, straw or green crops. Entries in the first two classes underwent trials in June as well as during last week when the Class C entries were tried out. All the trials were carried out under the supervision of Mr. S. J. Wright, M.I.Mech.E., consulting engineer to the Royal Agricultural Society. Reviving a custom which became established during earlier machinery trials of this nature, the Society gave a dinner on Monday evening to representatives of competing firms, the judges and a large company of engineering and farming guests. At the dinner the awards in the competition were announced as follows:—Class A, Gold Medal and £750 to Jones Brothers, Ltd., for the "Invicta" pick-up baler, and Silver Medal and £300 to International Harvester Company of Great Britain, Ltd., for "45" pick-up baler; Class B, Gold Medal and £750 to John Wilder, Ltd., for the Wilder-Steed pick-up loader; Silver Medal and £300 to Taskers of Andover, Ltd., for the Paterson buckrake, and a special Bronze Medal to Mr. F. J. Snook for his pick-up loader. In the prototype class, the two prizes originally offered were divided and four awards were made, £250 each going to Mr. J. R. Warburton for his cutter-chopper-loader, and to Mitchell Colman and Co. for a self-propelling cutter-chopper-loader, and £100 each to Fisher Humphries and Co., Ltd., for a cutter-chopper-loader, and Mr. V. J. Stephens for his steel tape tying pick-up baler.

Productivity Team on Welding

A SPECIALIST team on welding has left this country for a six weeks' tour of the United States under the auspices of the Anglo-American Council on Productivity. A wide range of industries is represented by the eighteen members of the team, which will be under the leadership of Dr. H. G. Taylor, the director of research of the British Welding Research Association. Amongst the members of the team are representatives of the constructional steelwork, chemical plant manufacture, locomotive, shipbuilding, electrical, sheet and strip metal and acetylene industries; Lloyd's Register of Shipping, Railway Executive, Institute of Welding, and the British Electricity Authority. The Trades Union Congress will be represented by the general secretaries of the National Society of Coppersmiths, Braziers and Metalworkers, and the United Society of Boilermakers and Iron and Steel Shipbuilders. Prior to sailing for America, members of the team visited plants in this country. The terms of reference for the team include study of welding equipment and technique; materials handling, preparation for welding and subsequent treatment; inspection and testing; costs, costing methods and welding efficiency, and working conditions and trade practices. In the United States the members of the team are to be divided into a main team to investigate heavier constructions and a subsidiary team for the lighter constructions and all forms of resistance welding.

The Better Use of Coal

THE first of a series of memorial lectures inaugurated by the National Smoke Abatement Society to honour its first president, Dr. H. A. Des Voeux, was given at the annual conference on Thursday, by Dr. D. T. A. Townend. In this lecture, entitled "Towards the Better Use of Coal," a wide authoritative survey was given of the new scientific study of coal and its uses. Pointing out that the scientific study of coal was quite a recent development, Dr. Townend showed how an understanding of its complex structure was being sought for by analysts, geologists and physical chemists. He told how Dr. Seyler had discovered in coal nine different components, each with a different way of reflecting light, and how he had devised a technique for measuring the different proportions of each in different samples of coal, thus enabling coals to be identified and classified. In describing the intricate changes that take place when coal is burned, Dr. Townend told how it had recently been found that less smoke was formed if inert gases, such as nitrogen and carbon dioxide, were passed through the fire. These gases are present in the flue gases and a reduction in smoke is observed if these are recirculated with the air supply to the fuel bed of the fire. He also dealt with the progress which had been made in the development of the new down-jet principle of combustion and pointed out that a relatively new and important development was concerned with the efficient use of small coal as source of energy for gas turbines.

Productivity in British Industry*

No. XII—PRODUCTIVITY IN CIVIL ENGINEERING.

By Lt.-Col. C. M. NORRIE, D.S.O., B.Sc.†

THE civil engineer generally associates the term "productivity" with the output of factory industries where assets and organisations can be created and maintained under conditions of permanence and continuity with the employment of regular staff and labour living in urban surroundings.

Each civil engineering construction site becomes its own factory for the time being, its assets are largely temporary contrivances to serve a short-lived purpose, nearly all its equipment and machinery is of a mobile or semi-mobile nature, its organisation has to accord with a changing variety of requirements as work proceeds and labour for the most part has to be recruited from those more used to casual than to regular employment and whose temporary housing and welfare may have to be arranged at the site. The more remote the site from urban centres the more difficult become the problems of transport, housing and the maintenance of supplies to keep a smooth running organisation intact and capable of achieving the highest possible production. Any attempt to compare the possibilities of productivity under such conditions with the frequently quoted "mass production" methods of factory production must therefore be tempered with understanding.

Even a comparison with the conditions prevailing in the building industry may lead to misleading conclusions. In the location of the works, their extent and time for construction, in the professional services engaged, the resources and experience of executive effort, and in the risks undertaken the differences between building and civil engineering are fundamental. This must not be taken to mean, however, that valuable experience cannot be learned by each from a close study of the organisation and methods adopted by the other. One of the difficulties in assessing the potentialities of the civil engineering industry to-day is the absence of separate reliable statistics of the resources and labour employed. Official analyses are still based on a grouping of the two industries as if there were a complete unity of interests.

So far as can be ascertained the annual turnover in value of civil engineering works under construction is at present about £120,000,000, and the number of men in employment about 175,000. Of this total, at least 60,000 may be classed as skilled of one kind or another and productivity in an increasing degree depends on their services. The ever-increasing mechanisation of the industry is accountable for a considerable reduction from pre-war total figures of employment and has entailed a change in the proportion of skilled workers required in a properly balanced labour force. The need in maintaining an economic balance is more and more becoming a question of finding labour sufficiently skilled to maintain and operate efficiently the increasing amount of labour-saving plant.

Incidentally, those who view, as a ready remedy for mass unemployment, an increase in the public works construction programme under modern conditions, may find many disappointments. It has been estimated that with even an increase in employment of 100,000, including an additional 30,000 classed as skilled workers, the complement of the latter class available would be strained and that beyond this limit economic production would not be attainable.

The introduction of mechanisation coming rapidly between wars and further developing since 1945 far outstripped the foresight and resources of plant manufacturers in this country. Imported machines, largely from the U.S.A., had to be purchased, experience in their operation learned by labour and changes in old methods of working devised by contractors to meet the new conditions. It is true that we in this country have been saved much pioneer experimental costs, but it is probable that with a more gradual development of our own resources better types of mechanics and operators accustomed to public works conditions and traditions would have evolved. The civil engineering industry is passing through a difficult transition stage in respect of greater mechanisation and in what may be termed a psychological readjustment of the post-war labour available in its employment.

To attempt a complete list of the mechanical appliances brought into general use by civil engineering contractors during the last fifty years would be of small practical value here. Beginning with the old steam navvy, originated in this country and developed to such magnitude in the U.S.A., the list is a long one. In earth moving, rock excavation, tunnelling, concrete mixing and placing, transport of materials and other branches, progress has been multiplied and improvement continuous in an evolution well known to those in the industry. If special mention need be accorded to any particular development the progress in concreting plant may be cited. The advances in design of mixers of all sizes have been marked by greater reliability and economy in operation. Batching plants, many automatic in their gauging, have ensured better measurement of segregated materials. For the transport and placing of the mixed product the power-driven concrete pump added to the labour-saving resources whilst the introduction of pneumatic or electrical vibrators gave a new tool ensuring better density to the concrete in situ. The latest addition in the sequence of aids is the pneumatic pressure placer which delivers a whole batch from the mixer in a single discharge through a pipe to the point of placing, the impact of delivery helping consolidation. In static resources, the greater availability of steel shuttering capable of multi-use in various forms has yielded better surface finish and economy in erection. One and all, plant innovations have entailed large capital expenditure, the annual charges on which constitute a considerable proportion nowadays of production costs. The criterion of their economic advantage has been that those charges and the running or using costs have, in sum, been less than the costs of the labour, and in cases the materials, rendered redundant by their use.

Mention should also be made of the new processes which affect production. Many of these have depended on the invention or adaptation of special plant as necessary means for their application. The sealing off of water-bearing strata by freezing or by chemical consolidation, the stabilisation of soils by various methods, the system of bore-hole pumps and well points for drying out excavations and the latest colloidal grout process of making concrete in situ, all, among other processes, open fresh possibilities in construction and play their part in enlarging the scope of economic production.

One of the concomitants in this ever-evolving situation has been the need to maintain and, where possible, improve, the quality of production. Engineers, quite naturally, have been conservative in their attitude towards the substitution of mechanical means for well tried manual construction methods in permanent work, and many have been slow to recognise in their designs and specifications the need for these more economic means of construction. In many instances mechanisation has improved quality. Few will deny to-day, for example, that a properly operated batch concrete mixer gives a more consistently good material than the old-time hand stage mixing. On the side of workmanship the placing of concrete by mechanical means has shown it can produce as good a result as the slower and often more difficult placing of the mix by hand methods. Generally, mechanised operation tuned to requirements, is more reliably consistent in quality than the unequal workmanship of inexperienced labour which unfortunately is so prevalent to-day. On repetitive or run work it can give excellent service, and where special circumstances are encountered, it can often be adapted without detriment to quality, although probably with less economic results. The engineer can help considerably, by ensuring that his designs and specifications do not create special circumstances which can be avoided without sacrificing the purpose to be attained. Another point deserving better attention sometimes is the advisability of more detailed site investigations for the location and use of local materials in construction or for the avoidance of natural conditions which are likely to retard production.

The measurement of productivity is a function of the cost and quantity of work done in a given time. Provided that the actual progress of performance to date does not lag behind the equivalent progress scheduled in the construction programme, the simplest and most practical index of efficiency is unit cost computed from totals reckoned cumulatively or over interim periods. Any excess of actual progress at completion may be a credit on the programme, but whether this will save in site overhead costs will depend on the relative importance of the particular operation in the programme. Generally, there will be some economic progress at which unit cost can be kept within a minimum range and the objective will be to maintain this progress unless the programme demands something different. The criterion for comparison of unit cost must be the schedule equivalents included as estimates in a contract price, the comparable elements being segregated into labour, plant and site overheads according to the system of costing which is found to be most practicable on each job. Obviously, the financial success of a contract

* No. I, "An Introductory Survey," by B. White, appeared February 17th; No. II, "The Threshold of Productivity," by F. A. Martin, March 3rd; No. III, "High Productivity and Production Costs," by Sir Claude Gibb and Gordon M. Baker, March 17th; No. IV, "Standardisation in the Aircraft Industry," by E. C. Bowyer, March 31st; No. V, "Restrictive Practices," by Arthur Woodburn, April 21st; No. VI, "Research for Productivity," by Dr. D. F. Galloway, May 19th; No. VII, "Consequences of Simplification," by W. D. King and H. Sherburn, June 30th; No. VIII, "Works Extensions," by C. K. F. Hague, July 28th and August 4th; No. IX, "Mechanical Handling" by F. Garner and A. Siddall, August 11th and 18th; No. X, "The Importance of the Craftsman," by F. V. Everard, September 1st: No. XI, "Productivity in the Smaller Engineering Works" by Antony Vickers, Sept. 15th.

† Chairman, John Cochrane and Sons, Ltd.

operation depends on the accuracy of the estimate made with due regard for the particular progress required.

Productivity is probably most conveniently gauged from week to week by the unit cost of labour employed as in the great majority of cases productivity still depends essentially on individual manual efforts or timely action at the site of operations. With increased mechanisation the question of total unit cost in some cases may become more a matter of the suitability, maintenance and operation of items of plant or power tools, and the efficiency of methods of working than one of assessment solely by direct manual productivity. The costs of plant maintenance are twofold—the direct costs and the consequential losses through delays for repairs.

Reference has already been made to the increasing proportion of skilled men required in a properly balanced labour force. The introduction of these skilled operators, who generally speaking, have a higher standard of living than the normal labourers, involves new problems in housing. In many cases only by providing more costly family quarters can this type of workman be induced to remain on isolated sites.

One of the difficulties to-day is the supply of efficient and responsibly minded public works mechanics and plant operators, the basic trouble being that so many of those professing experience have had no proper apprenticeship or learner training in their craft. Too often men who would be classed only as mechanics' labourers under factory conditions have to be employed on public works to do a fully skilled man's work, frequently under conditions of improvisation and of time stress. The inefficiency of this class of labour can create a high charge upon productivity. For plant operation it is quite usual nowadays, owing to labour scarcity, to train likely men on the site. Under tuition supervision they may show promise, but too large a proportion, when put on their own initiative, immediately shirk the responsibility and revert to former tasks or leave the works, all the expense of their tuition becoming a debit against productivity. The above difficulties are not due to a lack of proper wage differential, but are undoubtedly consequential on full employment which enables the worker to shift readily from one job to another without fear of unemployment and also removes the risk of unemployment from the less competent and less responsible minded. Another point that bears on productivity is that the increased employment of skilled trades has brought the industry into much closer contact with restrictive practices which may be in force in factories, but which have not hitherto been customary on public works. In this respect it is open to question whether trades unions in this country are as production minded as their counterparts in America.

Two interesting reports have recently been published—the Working Party Report on Building, by the Ministry of Works, and the Productivity Team Report on Building, by the Anglo-American Council on Productivity. Both are well worthy of close study by the civil engineering industry as many of the conclusions are directly applicable to its activities. Of special note in the latter report are the descriptions of conditions in the U.S.A., where the whole spirit of industry is tuned to a higher pitch by the competitive instinct. "Acceptance of the need for high productivity as an essential factor in industrial life is universal in America, and it permeates the will and action of the operatives as well as of the professional and employer groups. . . . The operatives, no less than the employees, realise that if the industry prices itself out of the market, there will be hardship for all. . . . Industries are less likely to achieve full health and efficiency if they are artificially shielded from the ordinary economic processes of competition." There is small doubt that in this country full employment has resulted in this shielded position of apparent security.

Individual production in the civil engineering industry generally has dropped below pre-war standards. Estimates vary between 60 and 80 per cent, but it is doubtful if such estimates are of real practical value owing to the difficulty of finding comparable assessments and to the difference in conditions governing the employment of labour in the post-war years. Again, to quote from the American report, "it is necessary to emphasise the vital part which the individual operative and his union officers must play in the struggle for increasingly higher productivity and progressive reduction in costs." The fact that output in America is so much higher than in this country depends "to a great extent upon the keenness and initiative of the individual workman." In this country there is no blinking the fact that there is an obvious lack of these qualities which so impressed the British team who visited the U.S.A. On the other hand, but not by way of excuse, it should be remembered that the extent of war aftermath and the home resources for recovery in the two countries are different. In the matter of diet alone, the conditions bear no similarity.

Overhead costs have increased relatively to the increased costs of labour by the need to comply with many controls and regulations which were thought to be of only wartime duration, by the collection of income tax through P.A.Y.E., the administration of holiday and welfare schemes, and by the constant effort required to find ready sources of stores and materials in restricted markets, and to expedite much-wanted deliveries. One of the most serious blows to any improvement in productivity was the coal crisis early in 1947, which affected gradually, but very surely, the economics of the civil engineering industry in that programmes for progress were delayed.

Incentives

On public works it has always been the practice to offer incentives dependent on output and this system continues to be applied wherever possible. Certain operations such as tunnelling, mass excavation, trench work, mass concrete and the like lend themselves to bonus on target working so long as there is the opportunity and the will in gangs to grade fairly the individual benefits earned. The theory of incentive schemes is that they afford an opportuntiy to give labour its proper share in the savings effected by higher productivity. The practical difficulties in civil engineering work often lie in assessing the real savings and in gauging the extent to which labour is able and willing to give increased output for a larger pay packet. A bonus which is not earned by output becomes merely attendance money which only encourages poor productivity. With full employment there has been a tendency among certain craftsmen to refuse participation in this traditional public works method of increasing productivity. An insistence on full week-end working with its overtime rates and without relation to output by these craftsmen has had to be accepted by contractors where the craft work is a key necessity in certain operations. This regrettable lack of co-operation can be met in many cases by changes in the engineering designs which, where possible, should be devised to eliminate the need for craft services in construction. The fixing of the scope and scale of bonus rates requires much experience in the capabilities and psychology of the labour concerned. Often a low target and bonus rate which starts benefit earning early in the period will result in better productivity than a high bonus which can only be earned when a high target is reached towards the end of a period. In the latter case the prospect of attainment may be marred early by unforeseen obstacles when at once the incentive for that period is removed. Incentives have the added advantage that they encourage workmen to take better care of their tools and to devise themselves the site ingenuities which facilitate productivity. On some works where efficient plant servicing is of special importance a scheme is in force for the mechanical branch whereby a bonus is paid so long as there are no breakdowns and is reduced or ceases altogether when the plant is out of operation through failure to forestall breakdowns.

Generally, the output on bonus working is sufficiently high to show that certain classes of post-war labour can work well when encouraged. If old standards of achievement cannot always be reached the reason is often inexperience, but this does not account for all. Absenteeism which throws gang efficiency out of gear and the constant changing of occupation fostered by full employment are important factors in the situation. On the smaller contracts where local labour can be selected and is sufficient to fill the demands these disturbing factors are not so noticeable, but on the larger, and especially the more isolated works where demand exceeds supply, the effects definitely reduce the standards of productivity.

Since the war there has been much interruption of productivity in the civil engineering, as in many other, industries, owing to short supply of engineering stores and materials. The export drive and the general demands for rehabilitation of war damage and for delayed repairs have all caused restrictions in the sources of supply. Improvement has been gradual, but a free prosecution of progress has in many cases been handicapped. In addition, exchange regulations have prevented the import of certain articles, the employment of which abroad has enabled distinct advances in productivity to be made. A notable example is Swedish high-grade steel for rock drills and the more easily handled machines for tunnelling work. These products were developed largely in a neutral country when our own steel works and factories were occupied on war work. Even when our own import restrictions were removed the foreign demands have been so great that supplies have been difficult to obtain. When they have been put into operation here the improvements in productivity have been noticeable.

Productivity as an economic problem is linked to political considerations. Under present-day circumstances a sense of duty applies to all, but differences in political doctrines and the opportunities they enlarge affect the contributions that can and should be made by different interests towards fuller productivity. In some circles an idea seems to prevail that full employment is the only objective and that productivity lies within the entire control of industry itself regardless of political influences or existing legislation. Any system of high taxation or controls which

inflicts undue direct burdens on earnings lessens the urge to give increased endeavour whether exerted by management or individual workers. For management the question remains as always the creation and maintenance of efficient organisation and the economic outlay of capital to keep abreast with evolving research and invention. A sense of frustration in this effort prevails in that returns are considered to be unduly taxed for the support of so many unproductive elements in Government expenditure. This inequality in balance of the whole national effort, uneconomic in itself, does not inspire confidence in industry which asks for good examples from those in authority who urge increased production. For the individual worker the income tax acts as a deterrent to best effort. It encourages a grudging view of the output he should freely give for standard pay, and, if he earns more by overtime, a readiness to average it by absenteeism, a multiplication of which in mechanised team operations can play havoc with planned production. When working on bonused operations it is not unusual for the taxed benefits to be calculated against different targets of performance and for self-set limits to be placed on the progress worth attaining. Calculation has even been applied to the value of absenteeism with tax remissions towards the end of the financial year. The result of all this ingenuity in tax evasion is a reduction in productivity efforts. The anomalies in the existing position can only be emphasised, the remedies lie in the hands of those who can influence political outlook and action.

The urgent needs for national economic recovery and the greater financial charges on increased capital expenditure on post-war development have tended to influence demands from promoters for the speedier planning and completion of public works so that occupation and revenue-earning stages may be earlier reached. These demands have not always assisted the industry in achieving high productivity. Too often the desire to save time has resulted in a lack of preliminary site investigations and an inadequate consideration of matters that are later found to be essential for efficient completion. The alterations in design and programme that become necessary when entry into the construction stage is unduly expedited, often make heavy demands on a construction organisation in staff services and overtime labour, all of which militate against high productivity. During the war a flexibility in design and programme was a necessity and had to be paid for heavily in many cases, but it is now urged that the overall economic value of time should be given a better consideration. As a rule, a more direct understanding of practical economics is found in private enterprise than under the divided responsibilities so often encountered in public ownership.

The British Association

No. III—(*Continued from page 287, Sept. 22nd*)

SESSION A of Section G (Engineering) on Friday, September 1st, discussed, jointly with Section A (Mathematics and Physics) and Section J (Psychology), the presentation of technical information. Sir Arthur Fleming presided.

Professor R. O. Kapp (University College, London), who opened the discussion, said that whilst there had been in the past a tendency to think of a scientist as dividing the whole of his working time between experimental work in his laboratory and mathematical work in his study, that picture was far from true to-day. The presentation of technical information was, at one time, of subordinate importance; now it dominated many of their activities. But the care and thought that had been given to the art of exposition were only slight in comparison with the manner in which research technique had been brought to a high standard. Yet there was no justification for neglecting this substantial part of a scientist's work. A scientist who would express his exasperation at badly constructed laboratory apparatus in the most vigorous terms was surprisingly tolerant of badly constructed reports and papers.

The field covered by the art of exposition was wider than might be supposed. There were scientific books and papers to learned societies; lectures, reports produced daily in offices and laboratories all over the world; technical literature issued by manufacturers in order that their customers could make proper use of the products, and discussions in conferences and committees. There was the question of illustrations, such as photographs, line drawings, diagrams of electrical connections, flow diagrams, curves, nomograms, conventional semi-representational pictures such as isotypes, and outside the field of published literature, but still within the field of the expositor's art were lantern slides, lecture demonstrations, display stands in showrooms, exhibitions and museums. There were also scientific films. These were all among the basic problems that arose whenever technical information had to be presented. The most important aspects of the expositor's art were linguistics, logic and psychology. Although the former was most often referred to he believed that mastery of the English language was less important than either logic or awareness of the person addressed. Although a good knowledge of school English was useful it was not essential, for an uneducated docker might surpass an English scholar in his ability as an expositor. Logic, however, was essential, for the art of exposition demanded, more than anything else, an understanding of the work done by a person to whom technical information was being presented. Those who would study this art must also study some aspects of psychology, such as the factors on which receptivity depends, the laws that govern the association of ideas and the way memory works. These were only a few of the aspects of psychology that had a strong bearing on the art of exposition.

How were we to set about the task of discovering and formulating the rules of good exposition? Three things were necessary. The first was to teach intellectual discipline in our universities and technical schools. The second was to provide a forum on which its problems could be discussed, such as was provided by each specialist institution or learned society, and the third was to provide a specialist literature in the subject of the new discipline. Activity had already begun in each of these three directions, though it had not gone very far in any of them. Systematic instruction in the art of exposition was available in a few, but only in a few, of our teaching institutions. The only forum of which he was aware was provided by a few, though admittedly active, discussion groups. The only literature on the art of exposition consisted of a rather small number of books; there was no periodical. He therefore suggested that the time had now arrived when more could and should be done in each of those three directions.

Mr. F. M. Colebrook (National Physical Laboratory) confined himself almost entirely to those special features of the writing of scientific and technical papers which arise when the author is a member of the paid staff of a scientific organisation—more particularly of a national, or at least non-commercial, organisation. The first distinctive feature, he said, was that the writing of papers by the staff of such organisations was, in general, a public duty, since such papers were sometimes the main return to the public for the public money spent. It followed that it was an obligation on the senior officers of such organisations to see that such papers were well written. Those who had been in senior positions knew that often involved a great deal of "chivvying," for to many scientific workers the writing of papers was a hideous chore, doubly damned by being itself a painful labour and by taking time that could otherwise be spent far more enjoyably in the laboratory. The practical problem, therefore, was very often the persuading of reluctant authors. It was helpful to stimulate interest in the writing of papers by means of talks and discussions on the technique of the subject, and that had been practised at the N.P.L. There was little or no deliberate training in the art in schools and universities; in fact, there seemed to be a general assumption that none was needed, though it was common experience that papers varied very greatly in readibility and effectiveness. The good name and reputation of the organisation as a whole was involved in the papers written by its individual members, and there was the reciprocal element that the individual author shared in and benefited from the reputation and standing of the organisation as a whole. Whilst anonymity had been the practice in some establishments there were much stronger reasons against it. It weakened the incentive to authorship, it was unfair to the author and it withheld useful, if not essential, information from the reader, in that the status and reputation of the author played a large part, and rightly so, in determining the attitude of the reader towards it. Furthermore, the names that appeared on papers should be those of the real authors. There had been instances, fortunately infrequent, where senior officers of organisations had had their names attached to papers to which they had, in fact, made little or no real contribution. The author suggested that that was a breach of professional ethics.

A POST-GRADUATE TRAINING COURSE.—At the New Southgate Works of Standard Telephones and Cables, Ltd., twenty-eight University graduates and technical college students have just begun a special training course, the fourth in the company's post-graduate training scheme. Lasting a full year, the course is designed to provide opportunities for candidates to relate their theoretical and practical training to the whole broad field of activities within the Standard organisation and to prepare them for the specialised duties to which they will later be assigned. The candidates are to spend three months attending a carefully prepared scheme of lectures, which forms the main syllabus, and will visit each of the company's principal locations. This will be followed by a period of study at the location to which the trainee will be posted.

Stourport "B" Power Station

ON Tuesday, September 26th, Admiral Sir William Tennant officially opened the B.E.A. Midland Division's Stourport, "B" power station, which has an initial installed capacity of 60MW. A second 60MW unit, which is expected to be in service in 1953, will complete the development of station "B," and, with the existing 180MW in the original station "A," will raise the total generating capacity of the site to 300MW.

As indicated on the accompanying site plan, the new station "B" lies immediately to the east of the old station "A," the intervening space being occupied by new workshops and stores, and by a new block of office buildings housing the staffs of both stations. Apart from the common administrative services, however, the two stations can be regarded as independent operational units.

Stourport "B" is a new station in more senses than one, for it embodies several interesting departures from the general trend of British power station practice. The steam conditions, for example, differ from the values of 900 lb per square inch at 900 deg. Fah., which have been adopted as the post-war standard for 60MW generating sets. Thus the first of the new 60MW sets operates at 1250 lb per square inch and 1250 deg. Fah., while the second set will use steam at 1500 lb per square inch and 1050 deg. Fah. Other points of technical interest about the station are the use of a slag-tap furnace for the first time in this country; the adoption of hydrogen cooling for the main alternator, and the installation of three independent heat pump systems to study the possibilities of recovering low-grade heat from the condenser cooling water and using it for space heating in the workshops and offices.

To meet the requirements of the new station the coal-handling facilities of the original station have been extended. A new stockyard has been made to the east of the existing storage space as indicated in the accompanying site plan. By means of the additional railway tracks, tippler and crusher, coal can be delivered directly to the bunkers or taken to or from stock. A single line of conveyors, with a capacity of 120 tons per hour, feeds the coal to the boiler bunkers.

At the other end of the combustion process the molten ash at the bottom of the furnace is drained into a water-filled ash hopper, where it disintegrates upon being quenched. The ash, in the form of small particles, is sluiced by "Hydro-Jet" plant into an external ash sump, whence it is hoisted by crane into overhead bunkers for final disposal by lorry to the dumping ground.

Dust from the various boiler passes, economisers and electrostatic precipitators is fed by "Hydro-Vactor" plant into bunkers, where it is damped down before being removed by lorry. An alternative method of ash disposal is to reintroduce the residue into the boiler combustion space for mixing and fusing with the molten slag on the furnace hearth; for this process special rams are mounted just above the slag bed.

Main Building Lay-Out

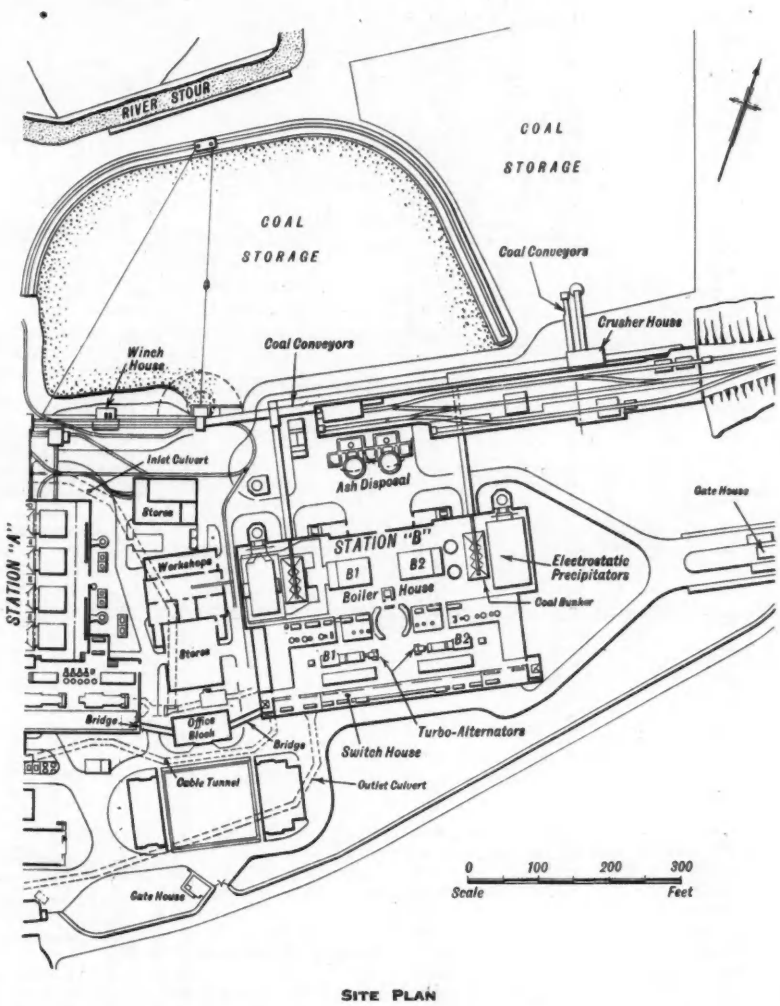
The main building is of steel-framed brick and, when completed, will occupy a space of about 408ft by 266ft. Two generating sets, arranged lengthwise, with their steam ends adjacent, will eventually occupy the 352ft long turbine house as shown in the site plan. With the aim of reducing noise, the walls and ceiling of the turbine house are lined with sound-absorbing sheet material. The surface of this sheeting is finished in aluminium, the reflective properties of which enhance the lighting of the turbine house.

In the boiler-house, which forms the northern part of the main building, the boilers are arranged with their front-to-rear axes parallel to the generating sets. To minimise the number of access galleries around the boilers the operating and tank floors are extended to surround the main boiler structure.

Sited between the first generating set and its boiler is the unit control board, arranged in an arc to face the corresponding control board which will serve the second set. When the station is complete, therefore, all the controls for the boilers, turbines and main auxiliaries will be grouped together in this central area.

Adjoining the south-east side of the main building is a switch house. As indicated in the sectional drawing of the power station, the main air-break switchgear and busbars are installed in the four upper floors of the switch house; the control panels and auxiliary switchgear are at operating floor level; below this there is a cable cell, while the main and auxiliary transformers are accommodated at basement level.

An unusual provision is the arrangement for maintaining an even temperature in the switch house to prevent condensation in cold weather: for this purpose use is made of the warmed air discharged from the exciters after cooling them. Effective distribution of the warm air into the switch house is achieved through suitably spaced ducts.



SITE PLAN

Boiler Plant

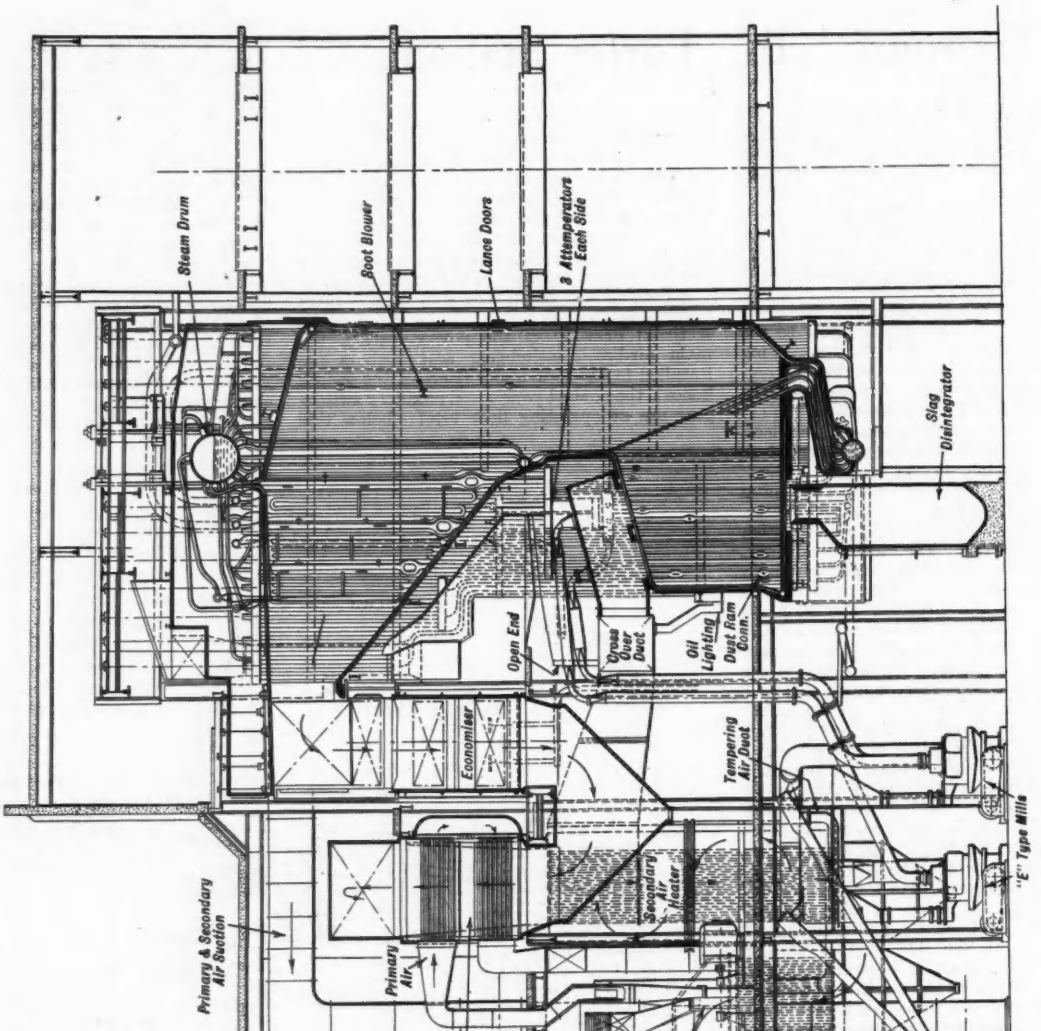
Technically, the boiler supplying steam to the first 60MW set is interesting, first, because it is a high-pressure unit, and secondly, because it makes use of the slag-tap furnace. The boiler has a maximum continuous rating of 525,000 lb of steam per hour, operating at a pressure of 1275 lb per square inch with an outlet superheat temperature of 975 deg. Fah., the feed-water temperature at the economiser inlet being 460 deg Fah. It is a two-drum unit, both drums being of welded construction with hemispherical forged steel ends.

Our sectional drawing of the boiler shows that the combustion chamber is divided into two portions. In the primary furnace the burners are arranged to fire downwards from the arch, keeping the ash in a molten state. The furnace floor is designed for continuous slag tapping, the floor being made up of water tubes protected by cast iron blocks and chrome ore. The molten ash is discharged over a small weir which ensures that a certain amount of slag is always retained on the chrome ore bed. A water-filled hopper below the furnace floor receives the molten slag, which disintegrates upon immersion and is then ready for sluicing away.

The secondary furnace forms the dry ash portion of the combustion chamber, and is separated from the primary furnace by a water-cooled slag screen. All the walls are of water tube construction; the secondary furnace walls present what is virtually a solid metal face to the hot gases, the tubes being of 3½in outside diameter, spaced at 3¾in centres. At continuous maximum rating the designed heat release is 21,000 B.Th.U. per cubic foot of combustion space.

Referring to the drawing of the boiler plant, the steam drum, which is 5ft 6in in diameter, and the lower drum, which is 2ft 6in in diameter, are connected at each end by a 17in diameter circulation pipe. Circulation back to the steam drum is provided by all the generation tubes in parallel. The fact that there are no intermediate drums implies the expectation of high velocities. Accordingly, to ensure effective

STOURPORT 'B' POWER STATION, MIDLANDS DIVISION, B.E.A.



separation of steam from water, with a quiescent water level and a minimum of carry over, it is arranged that all circulation tubes enter the steam drum via an annular space. Thence the mixture of steam and water cannot enter the main steam and water spaces without passing through cyclone separators.

Superheat control is achieved by thermostatically maintained attemperators between the primary and secondary passes of the pendant type superheater, which has a total heating surface of 19,238 square feet.

The steaming economiser, which is of continuous loop construction, is housed between the primary and secondary air heaters and has an effective heating surface of 2290 square feet. To reduce the amount of chemical dosing required a recirculating water pump is installed, drawing water from the boiler drum and reintroducing it to the feed system before entry into the economiser.

Primary and secondary tubular air heaters are provided. The primary section, which is arranged between the outlet from the superheater and the economiser, supplies air at the required temperature for the pulverising mills. It consists of horizontally disposed tubes with the air passing inside and the gases outside, the total heating surface being 17,700 square feet. The secondary heaters, which provide combustion air, have a total heating surface of 148,600 square feet, in the form of vertically disposed tubes carrying the gases inside and the air outside.

On leaving the air heaters the flue gases pass through an electrostatic dust precipitator, and thence, via the induced draught fans, to the chimney. When operating at normal full-load conditions, with an efficiency of 96½ per cent, the precipitator is expected to pass to atmosphere no more than 0·21 grains of dust per cubic foot of gas.

Provision is made for continuous or intermittent blowdown, as required. Soot blowing is effected by electrically operated blowers, comprising fifteen retractable units installed in the secondary furnace, four rack units in the secondary superheater and six multi-jet units in the primary superheater.

After being weighed at the bunker outlets the coal is carried by small Redler conveyors to transit hoppers placed above the pulverising mills, the feed being determined by automatic switching based on the coal level. There are four "E" type mills of a size calculated to maintain full boiler output, allowing a repair cycle of one mill out of service every four months. Each mill feeds two multi-jet burners disposed to give downward-burning flames. Oil-fired burners are provided for initial lighting; to facilitate preliminary testing and running in of the turbine, additional oil burners, capable of sustaining a boiler output of up to 60,000 lb of steam per hour, are installed.

Despite the fact that the furnace is designed to burn normal grades of coal, close control of quality is essential because, if unsuitable fuel were used, the slag might fail to reach its fusing temperature. For this reason provison is made for continuous sampling of fuel. Sampling points are provided on the connecting pipes between the mills and burners; in addition, there is an auxiliary sampling plant associated with the travelling tripper that distributes the incoming coal into the main bunkers. Samples taken periodically from this auxiliary plant are collected from the main conveyor belt, fed into a small pulverising mill and then taken by a subsidiary conveyor system into the chemical laboratory for analysis.

Combustion control is fully automatic, the control system being compressed air operated. The main functions of the system are to vary the speeds of the fan motors and the mill feeder motors, as required, to give efficient combustion. To give fine control over a wide range of load and steaming conditions the fans, which are driven by squirrel-cage motors, are fitted with variable-slip eddy current couplings. The mill feeders are driven by two-speed squirrel-cage motors.

Three main feed-water pumping units are installed, two being motor driven and the third, steam turbine driven. Each of the motor-driven sets comprises a low-pressure pump and a high-pressure pump, operating in tandem and capable of delivering a maximum of 650,000 lb of water per hour against full-load boiler drum pressure, or of pumping 525,000 lb per hour (the full rated evaporation of the boiler) against full blow-off pressure. The steam-driven pump acts as an automatic standby to whichever of the main pumping units that is in service.

Boiler feed is controlled by the Bailey three-element system of co-ordinating water level, steam flow and feed flow. The control is exercised by varying the speed of the low-pressure motor drive of the tandem unit, or of the steam pump, down to roughly half capacity, below which a throttling control takes over. The low-pressure elements of the pumping units are driven by a.c. commutator motors controlled by induction regulators.

All the boiler and feed-water controls and instruments, together with the equipment associated with automatic sequence soot blowing, are grouped, alongside the corresponding turbine controls, on sections of the main unit control board, which is illustrated overleaf.

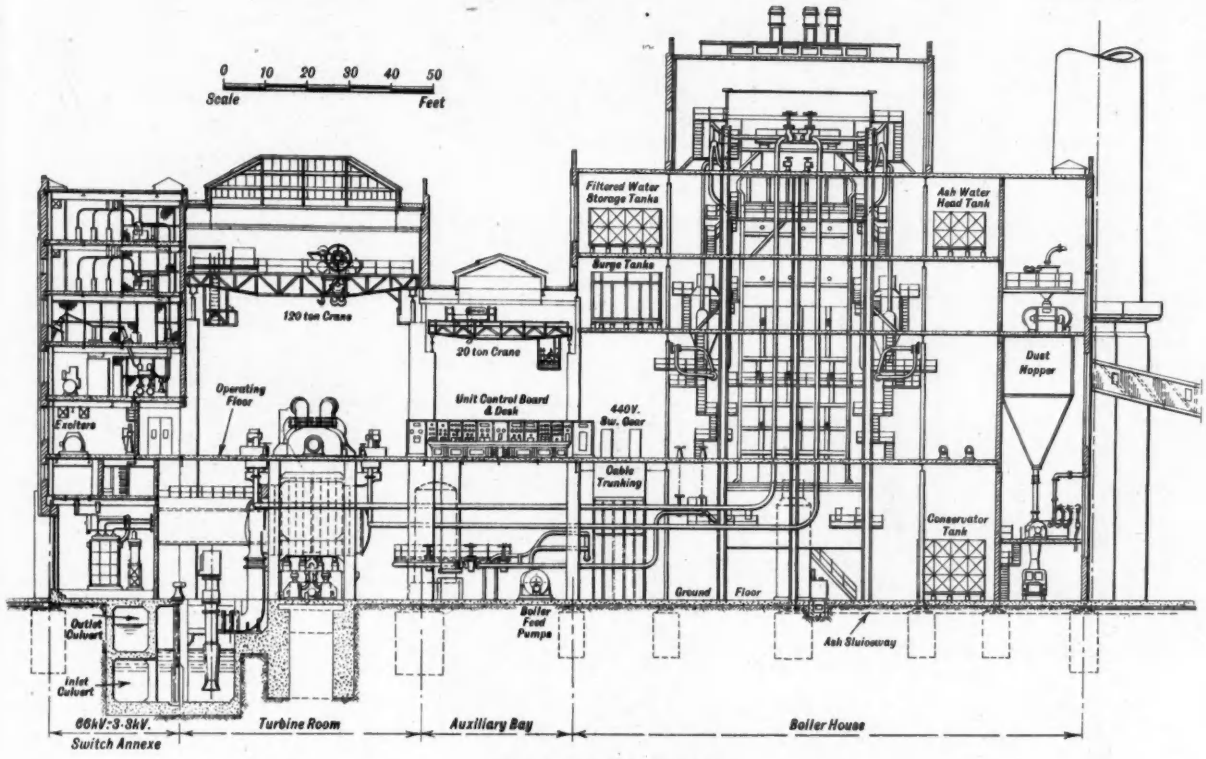
The Turbo-Alternator

The turbo-alternator consists of a three-cylinder turbine, running at 3000 r.p.m., direct coupled to the main alternator, with a 4500kW auxiliary alternator in tandem, as illustrated overleaf.

The turbine operates with stop-valve conditions of 1250 lb per square inch and 950 deg. Fah., exhausting to twin condensers designed to maintain a vacuum equivalent to 1·25in pressure absolute. Five-stage feed heating, provided by two low-pressure contact heaters and three high-pressure surface heaters, gives a final feed temperature of 460 deg. Fah. Evaporators and de-aerators are included to condition the make-up water or surge tank water introduced into the closed feed system. Duplicate 100 per cent capacity pumps are installed and there are three ejectors—two of 60 per cent capacity and one of 40 per cent capacity—together with a quick-starting ejector.

Circulating water is supplied to the condensers by two axial-flow pumps. Two vertical-spindle motors provide the cooling water requirements of the oil, air and hydrogen coolers. All the pumps are motor driven and variable-slip eddy-current couplings are included in the main circulating pump drives, so that the delivery can be varied in accordance with river temperature conditions.

In this installation the normal atmospheric relief valve and associated piping is dispensed with. Instead, the low-pressure turbine casings are fitted with explosion diaphragms. They are designed to operate, together with a load-shedding device and a trip, which will shut down the set before the pressure rise in the condensers can approach the bursting pressure



POWER STATION SECTION

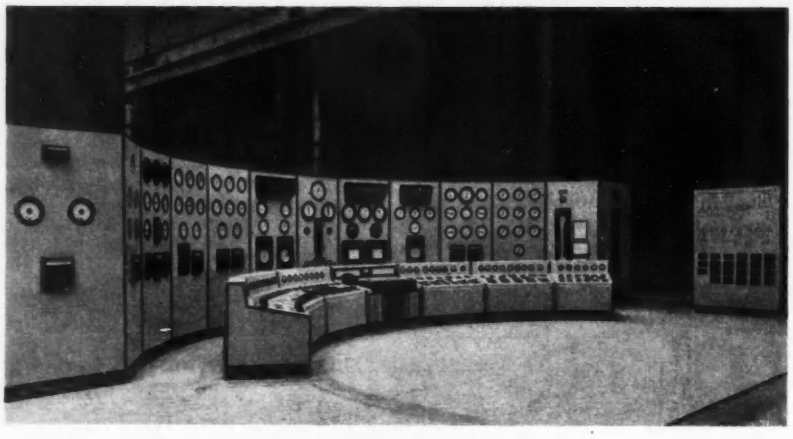
of the diaphragms. Besides the usual turbine metering and recording facilities, supervisory instruments are provided for recording vibration, shaft deflection and differential expansion.

When operating with the cooling hydrogen at a pressure of 0·5 lb per square inch gauge, the main alternator has a maximum continuous rating of 55·5MW at 0·8 p.f. By increasing the hydrogen pressure to 15 lb per square inch gauge, however, the output can be increased to 60MW if the house service alternator should be out of commission.

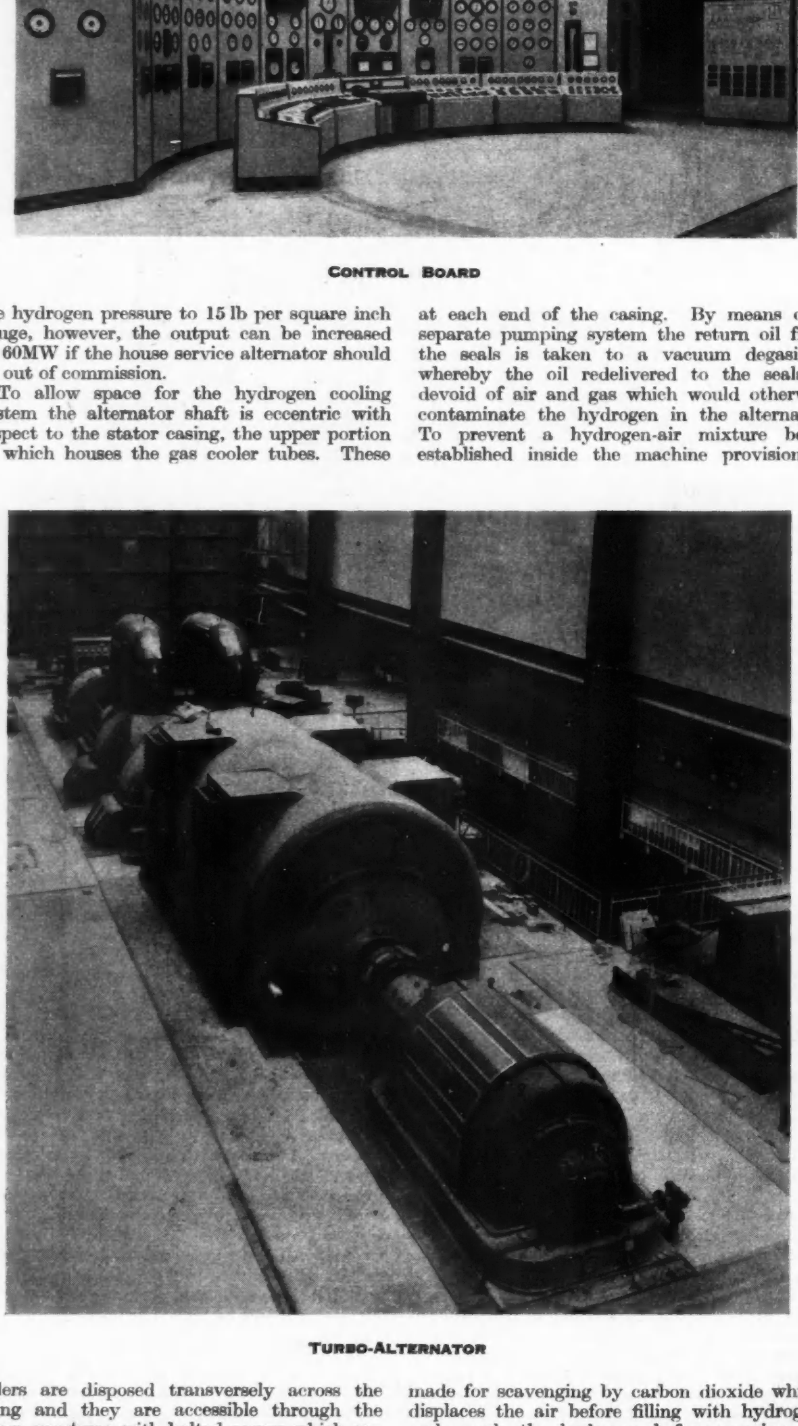
To allow space for the hydrogen cooling system the alternator shaft is eccentric with respect to the stator casing, the upper portion of which houses the gas cooler tubes. These coolers are disposed transversely across the casing and they are accessible through the square apertures with bolted covers which can be seen on the left of the accompanying illustration of the turbo-alternator. Cooling is effected by passing water through the cooling tubes, while the hydrogen is circulated round the coolers inside the casing by propeller fans fitted on the rotor shaft.

The stator core and winding was built as a separate assembly, which was fitted into the alternator shell on site, the core being flexibly mounted to minimise vibration effects.

Gas-tight oil seals are provided on the shaft at each end of the casing. By means of a separate pumping system the return oil from the seals is taken to a vacuum degasifier, whereby the oil redelivered to the seals is devoid of air and gas which would otherwise contaminate the hydrogen in the alternator. To prevent a hydrogen-air mixture being established inside the machine provision is made for scavenging by carbon dioxide which displaces the air before filling with hydrogen and expels the hydrogen before opening up the casing. These precautions should prevent the formation of an explosive mixture, but, as an added safeguard, the outer casing, which is of welded steel plate, is designed to withstand the maximum pressure that could be generated by an internal explosion.



CONTROL BOARD



TURBO-ALTERNATOR

A separate control panel gives a continuous record of the state of the hydrogen, by indicating the gas pressure, temperature and purity.

Supplies for the station auxiliaries are derived from the house service alternator—which is a conventional air-cooled machine with a capacity of 4500kW at 3·3kV, 0·7 p.f.

In keeping with a recent trend, instead of directly driven exciters there are two motor-driven exciter sets, one of which serves as a standby. Each set comprises a motor driving two main exciters (one for each alternator) and a constant voltage pilot exciter which supplies the fields of both main exciters. Besides the usual automatic voltage regulator a stability regulator is installed to prevent the excitation from falling below the safe stability limit, in the event of the main alternator operating on leading power factor.

Electrical Arrangements

An outdoor transformer steps up the output of the main alternator from 11kV to 66kV for handling by the main switchgear, which consists of air-blast circuit breakers of 1500MVA breaking capacity, and air-break isolating switches. For ease of control all this switchgear is electro-pneumatically operated from the control room. Control of station "B" switchgear can be exercised from the main control room in station "A."

The general lay-out of the main switchgear is characterised by the absence of steel or brick cubicles. Instead, steel mesh screens serve to separate the circuit breakers, isolators and busbars and to provide safe access passages, leaving the equipment completely visible, as indicated in one of our illustrations.

To eliminate cable connections where possible in the generator circuits, bare copper bars are used between the generator transformer and the switchgear, and between the switchgear and the main station auxiliary transformer. Oil-filled single-core cables are used for the outgoing feeders and the interconnectors to the switchgear in station "A." Fire-fighting apparatus is installed near the sealing ends, in the only part of the switch house containing any oil-filled equipment.

When starting up, or when the house set is out of commission, a supply for the auxiliary plant can be taken from a house transformer energised from the 66kV busbars. The auxiliary switchgear, which, as stated, is at the turbine operating floor level, consists of 3·3kV air-break units mounted in withdrawable trucks; the associated control and relay panels divide the switch annexe from the turbine room. Step-down transformers provide a 400V supply for the smaller motors, while the larger motors operate directly at 3·3kV. Air-insulated contactor gear, forming a central board on the operating floor near the boiler, controls the smaller motors. All motors are controlled from the main unit control board, which incorporates a switch, ammeter and indicating lamps for each motor.

To avoid the confusion that might be caused by having a large number of separate alarm bells or hooters for various fault conditions, alarm annunciation is centralised on the control desk, which is illustrated on this page. This system provides one audible alarm together with visible indication of ninety separate alarm conditions. When any emergency arises, therefore, the appropriate lamp on the annunciator panel begins to flash, and the audible alarm is sounded. Operation of a central push button then silences the audible alarm and converts the flashing lamp signal into a steady signal. This lamp signal persists until the alarm condition has been cleared. If another alarm condition should occur before the previous one has been cleared, it will operate the audible alarm as well as the appropriate flashing lamp signal.

A similar scheme is installed in the main control room to provide central alarm annunciation for all the switchgear.

Output from the station is transmitted through the 66kV switchgear to an outdoor grid substation, east of the Worcester road.

This substation is of lattice steel construction, with high double busbar lay-out. It incorporates bulk oil circuit breakers to control the step-up transformers and the 132kV overhead lines connecting it to Ocker Hill, Bartley Green and Worcester. The total transformer capacity of 120MVA is made up of one 60MVA unit and two 30MVA units.

Stourport "A" power station, it may be recalled, was owned and operated, prior to vesting day, by the Shropshire and Worcestershire Electric Power Company, which was responsible for the original conception of the new station "B." Design work on the first half of this station was started in 1943 upon receipt of a direction from the Central Electricity Board. The consulting engineers responsible for the work are Ewbank and Partners, Ltd., the architects being Messrs. Farmer and Dark.

Principal Contractors

The principal contractors for the first 60MW unit are :

Civil and building works, roads, culverts, floors, walls, roofs, &c., Sir Robert McAlpine and Sons, Ltd.; steelwork, Dorman, Long and Co., Ltd.; boiler unit, Stirling Boiler Company, Ltd.; boiler fans, Howdens, Ltd.; electrostatic precipitator, Sturtevant Engineering Company, Ltd.; chimney, Chimneys, Ltd.; turbo-alternator and auxiliaries, English Electric Company, Ltd.; condensing and feed heating plant, English Electric Company, Ltd., Hick Hargreaves and Co., Ltd.; boiler feed pumps, G. and J. Weir, Ltd.; main circulating water pumps, Drysdale and Co., Ltd.; auxiliary circulating water pumps, Harland Engineering Company, Ltd.; coal-handling plant, Spencer (Melksham), Ltd.; coal feed to P.F. mills, Redler Conveyors, Ltd.; ash and dust-handling plant, Babcock and Wilcox, Ltd.; ash-handling crane, Sir Wm. Arroll and Co., Ltd.; h.p. and l.p. pipework, Aiton and Co., Ltd.; h.p. valves, Hopkinsons, Ltd.; engine room crane, Stothert and Pitt, Ltd.; pump aisle crane, Herbert Morris, Ltd.; unit control board and automatic combustion control, Bailey Meters and Controls, Ltd.; fire-extinguishing plant, Mather and Platt, Ltd.; circulating water band screen, F. W. Brackett and Co., Ltd.; stationary circulating water screens, Ledward and Beckett, Ltd.; heat pump plant, Rosser and Russell, Ltd.; vacuum cleaning plant, Sturtevant Engineering Company, Ltd.; storage tanks, South Durham Steel and Iron Company, Ltd.; raw water filters, United Filters and Engineering, Ltd.; transformers, switchgear (66kV and 33kV), English Electric Company, Ltd.; oil-filled cables (66kV), Pirelli-General Cable Works, Ltd.; contactor panels (400V), Contactor Switchgear, Ltd.; mercury arc rectifiers, English Electric Company, Ltd.; station battery, Chloride Electrical Storage Company, Ltd.; telephone and alarm equipment, Standard Telephones and Cables, Ltd.; cabling and wiring, London Electricity Board.

Aluminium Strip Mill at Rogerstone

No. I

At the Rogerstone Works, near Newport, Monmouthshire, of the Northern Aluminium Company, Ltd., there has just been completed a new continuous aluminium strip mill, and through the courtesy of the company we were able to be present at the formal opening ceremony by the Right Honourable G. R. Strauss, M.P., the Minister of Supply, and to make an inspection of the works, which can be seen in our illustrations.

Post-war conditions, with their economic pressure to reduce costs, coupled with the necessity of entering new markets, could only be met by utilising up-to-date plant and modern production methods. The obvious site for the new factory was as an extension to the Rogerstone works, with its proximity to adequate supplies of coal, coke, gas, electricity and soft water for process use, backed by excellent communications by road and rail with the Bristol Channel ports, ready availability of labour and the existence of ample space. Consideration of market requirements indicated that the greatest demand was for work hardening materials, such as commercially pure aluminium and the 1¼ per cent manganese aluminium alloy. So as a measure of standardisation the mill has been designed to produce sheet in these alloys, but could produce strong alloys, for which purpose provision has been made for two additional mill stands in the hot line. Mechanical handling has been introduced wherever possible and it is expected that the output per man will reach as much as five times the previous best. The present capacity of the plant is 50,000 tons per annum, with the hot line working one shift per day, so that production could be greatly increased by the addition of extended cold rolling and finishing equipment, for which space is available.

Mill Buildings

The mill is on the north bank of the River Ebbw; no piling was found necessary and the difference in east and west ground levels has been absorbed by two changes of floor level. With the water table only 2ft below datum the foundations had to be made water-tight and they also had to be deep enough to provide for ventilation ducts, service tunnels, busbar runs and an oil cellar under No. 1 finishing bay. A total of 65,000 tons of concrete and 410 tons of steel reinforcing rod were used and 61,000 cubic yards excavated. The steel-framed main buildings, with a cubical content of 15,750,000 cubic feet and involving the erection of 3000 tons of steel, are covered with corrugated aluminium sheet and have stanchions spaced at 30ft centres and roof trusses spaced 15ft apart at a height of 33ft 6in, with purlins spaced at 4ft 6in on the roof and 5ft 6in on the walls.

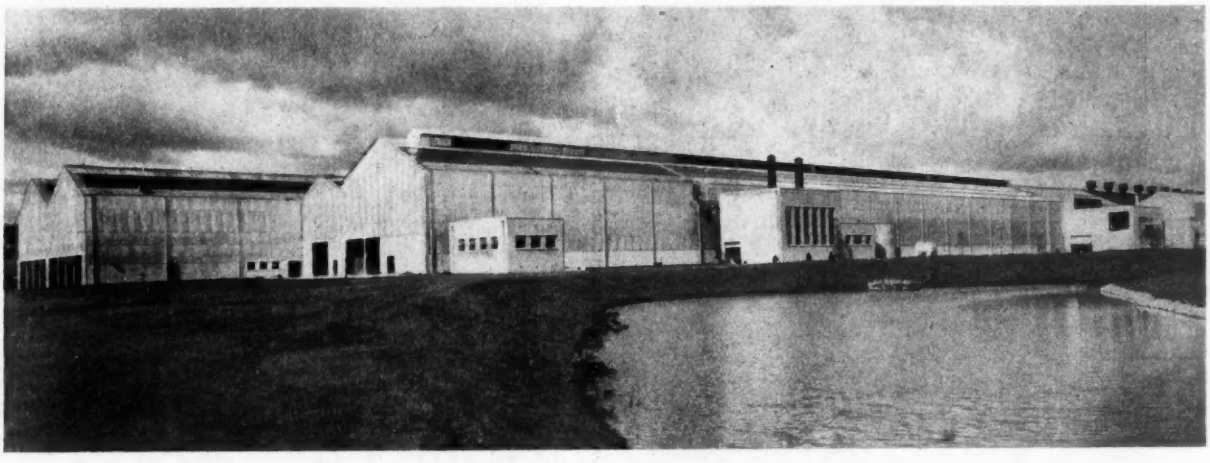
A double skin of corrugated aluminium alloy sheeting, amounting to 200 tons, was used for the roof and walls, the outer skin being 20 S.W.G., the lining 26 S.W.G., and the roof-capping 22 S.W.G., all fastened by aluminium alloy hook bolts, nuts and diamond washers. Guttering and downpipes are of half-hard aluminium alloy. An illustration on the next page gives a general view of the structure.

Equable temperature is maintained in the buildings by the extensive use of aluminium foil insulation, which consists of three layers of corrugated foil stuck together and the resulting panels laid between the purlins. It is expected that the overall thermal conductivity of the sheeting and foil will be 0·3 B.Th.U. per square foot per hour, per 1 deg. Fah. rise in temperature, at which figure the space-heating requirements will be reduced by one-third and the resulting saving in capital cost of the heating plant will defray 60 per cent of the insulating cost, the remaining 40 per cent being paid for within eighteen months by the savings effected on the fuel bills.

Aluminium alloys have been widely used for many other fittings, such as access ladders, walkways, glazing bars, doors of various patterns, mill control cabins and aluminium paint has been applied to steelwork and other surfaces.

Plant Lay-Out

From the accompanying diagrammatic flow chart the sequence of operations can be readily seen. Scrap and pure pig aluminium pass through the reheat processes of the melting furnaces, holding furnaces and are then cast, the resulting ingots being joined by those imported from Canada. On the first stage of their journey through the mill the ingots are scalped and then preheated before joining the hot line. Here they pass through two hot mills, followed by shearing and trimming, after which there is a two-stand hot finishing mill; then the slab is cooled, sheared and trimmed and coiled before being passed on to a three-stand tandem cold mill. From this point the treatment for the various end products ceases to be common. Coil for building sheet is passed to the heavy shear line, to be flattened, sheared and corrugated. The remaining coils pass through the slitter and here the material for circles is diverted to a blanking press and the other material is annealed, some is earmarked for foil stock and the rest, classified as container sheet, proceeds through the temper mill, where it is degreased, trimmed, sheared and sorted.

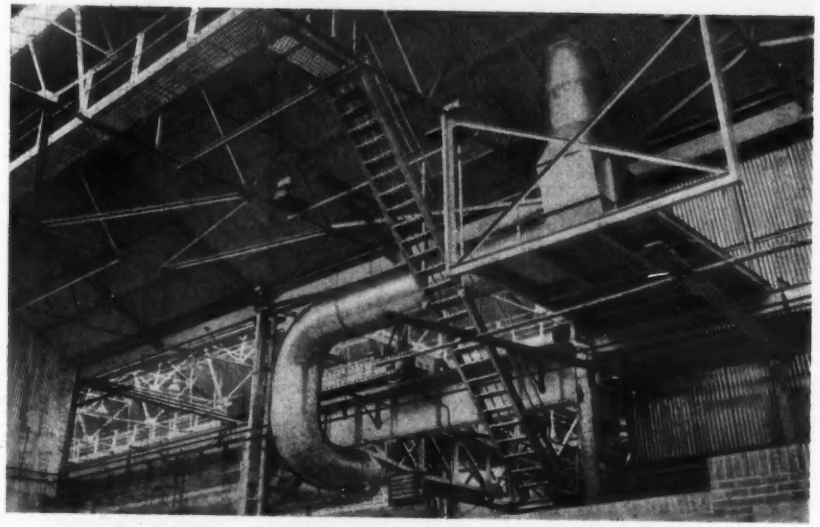


THE MILL FROM THE EAST

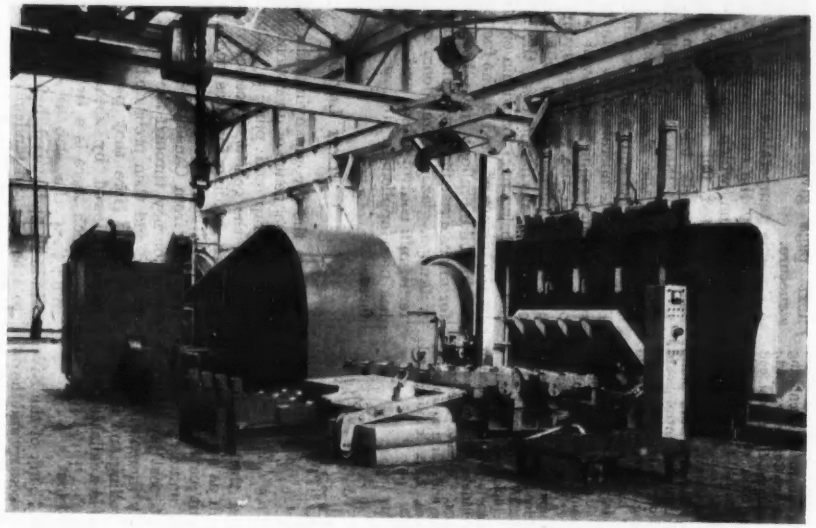
Remelting of Scrap

Rejected sheet and the considerable quantities of scrap from the trimming and shearing operations are remelted in low frequency induction furnaces, of which two are by Siemens-Schuckert (Great Britain), Ltd., and two of American Tama pattern, by Birlec, Ltd. Fully charged, each two-bath alumina brick-lined Siemens-Schuckert furnace holds 10,900 lb,

ALUMINIUM STRIP MILL AT ROGERSTONE

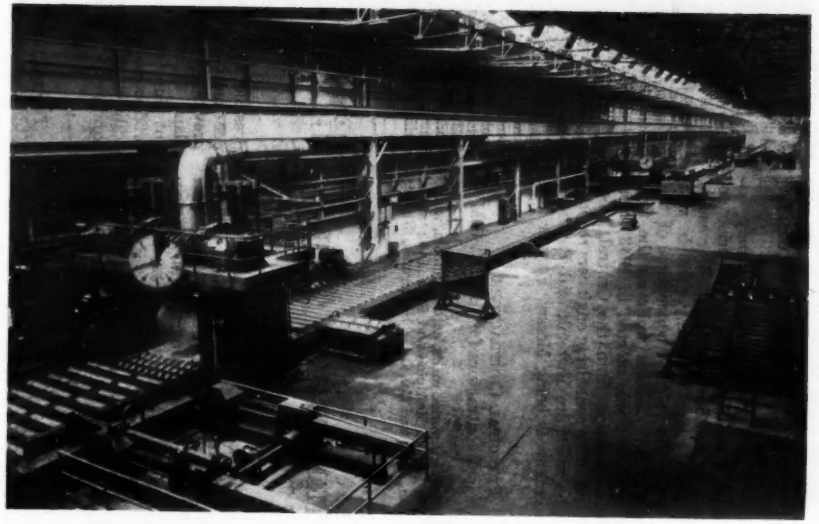


TYPICAL INTERNAL VIEW OF STRUCTURE



SCALPING MACHINE

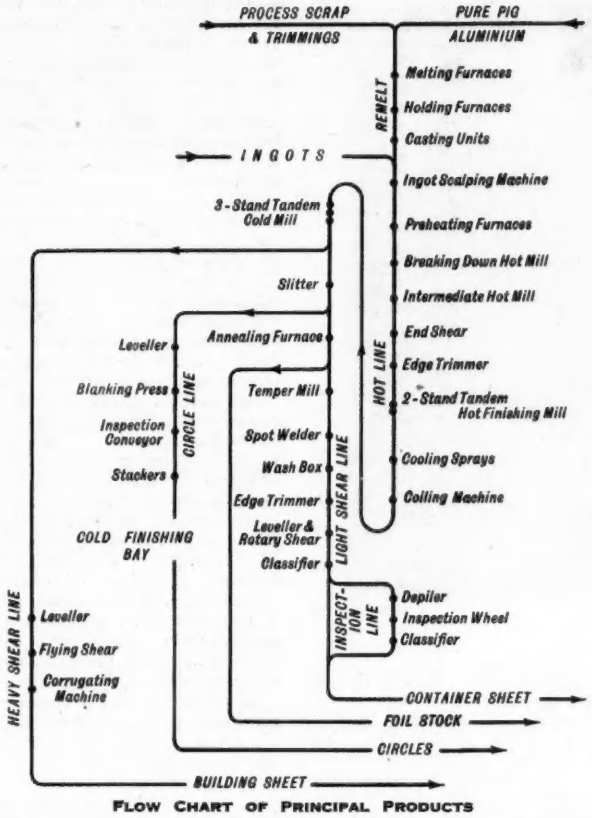
PREHEATING FURNACE



HOT LINE

of which 7400 lb can be tapped. The furnace is rated to produce 6000 lb every three hours, the metal being removed by an iron siphon pipe at 2000 lb per minute, an electrically driven vacuum pump providing the initial lift. The air-cooled furnace transformer is rated at 400kW. Having a single bath, the Birlec Tama furnace has vertical melting channels, the rating is 500kW and 7500 lb of metal are melted per three-hour cycle.

For pouring after melting there are four resistance-heated holding furnaces, each having a 11,000 lb capacity bath and a maximum loading of 165kW. The metal is poured through launders to two semi-continuous casting units, in which the shallow mould is water-cooled. Supported on a hydraulic ram, having a stroke of 10ft 6in, the floor of the mould is lowered at a speed up to 6in per minute, as the metal cools, to produce ingots of 60in by 12in section and a maximum weight of 9000 lb.



FLOW CHART OF PRINCIPAL PRODUCTS

It is necessary to remove the rough surface of the ingots before rolling and for this purpose there is an Ingersoll horizontal spindle milling machine, as illustrated. The machine, which can deal with ingots from 40in to 120in long, 28in to 58in wide and from 6in to 12in thick, has a 74in diameter cutting head, holding forty-two roughing tools and two finishing tools, driven at 125 r.p.m. by a 500 h.p. a.c. motor, and capable of cutting at a speed between 30in and 180in per minute. Holding the ingot by hydraulic clamps, the work table approaches the cutter at 75ft per minute and a manipulator, actuated by a Weatherly oil gear pump, loads and turns the ingots. Scrap is conveyed to a Jeffrey Diamond hammer crusher, driven by a 75 h.p. motor.

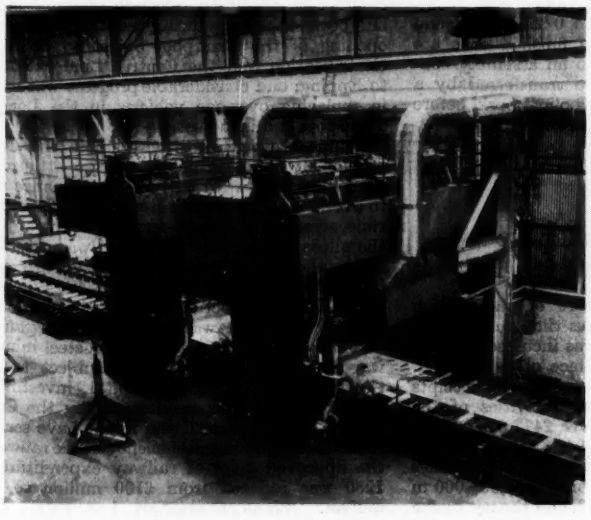
Now ready for preheating, the ingots are loaded into two gas-fired furnaces and two of electric resistance pattern, which can be seen in the photograph on the previous page. Heated by producer gas of 185 B.Th.U. per cubic foot calorific value, each single-arched chamber Priest furnace has a length of 51ft 3in and a width of 9ft and contains forty chairs in two rows, each chair taking a maximum weight of 205 lb. A 6 h.p. 25in diameter Sirocco fan, delivering 1850 cubic feet per minute at 8in w.g., supplies air for the burners and the hot gases are recirculated by a 50 h.p. 40in diameter Keith Blackman fan, rated at 22,800 cubic feet per minute at 1½in w.g. and 550 deg. Cent. Each G.W.B. furnace has an internal length of 57ft 8in, divided by ring arches into six zones, each with 15 h.p. centrifugal fan in the roof to circulate air over the elements, which take a load of 3750kW, subsequently reduced to about 85kW after the correct temperature has been attained.

A heavy chain conveyor transfers the scalped ingots to each pair of furnaces and a 75-ton capacity hydraulic ram pushes the ingots into the furnaces after weighing. Having a 60ft span, the Wellman Smith Owen overhead discharging machine, seen in the illustration of the preheating furnaces, picks up the hot ingots and conveys them to the six-roll receiver table at the beginning of the hot line, which is illustrated on page 320.

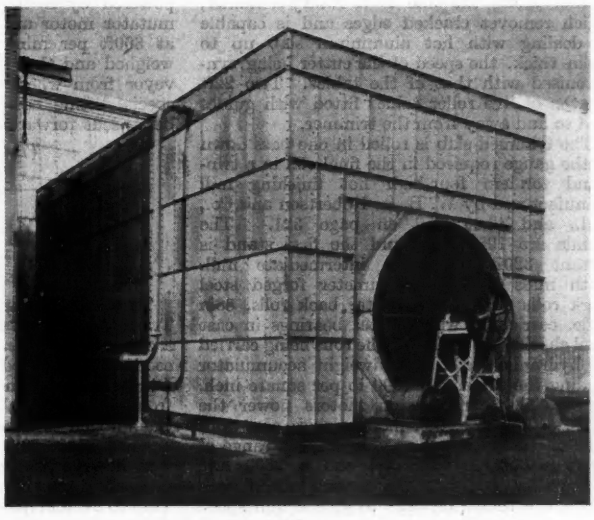
Hot Line

A feed table, 108ft long, composed of 14in diameter chilled cast iron rollers at 15in centres, driven by line shafts and bevel gears and absorbing 3 h.p. per roll, moves the ingot to the split roller table at the ingoing side of the mill. With a maximum speed of 450ft per minute, the two-high reversing breaking down hot mill, built by the Brightside Foundry and Engineering Company, Ltd., has forged steel rolls, 35in diameter by 96in long, weighing 16½ tons, carried in Bakelised fabric bearings and cooled by a 2 per cent Sternol soft water emulsion delivered at 900 gallons per minute, and 35 lb per square inch by a Mather and Platt pump. The warm oil is pumped to a Premier cooling tower, which cools 900 gallons per minute from 82deg. to 68 deg. Fah. at 58 per cent humidity. The total capacity of the warmed and cooled tanks is 11,000 gallons. Power for the mill is supplied by a British Thomson-Houston 2000 h.p. d.c. motor, with which the roller table motors are synchronised. There is a 94ft long outgoing table, similar to the feed table, with the last section of the rolls under the control of the operator of the next mill and each table is equipped with a pair of hydraulically operated pushers for centring the ingot. The maximum width of slab which can be rolled is 78in and it is subjected to five or more passes, during which the thickness is reduced from 9in to 2½in.

Borne along the three sections of the 86ft long feed table, the slab, controlled by automatic hydraulic guides, enters the Brightside



TWO-STAND HOT FINISHING MILL



WATER COOLER

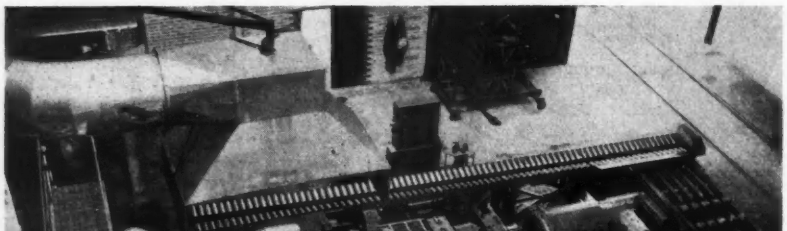
intermediate mill, which has rolls of 32in diameter by 84in long, driven by a British Thomson-Houston 1650 h.p. d.c. motor, giving a slab speed of 420ft per minute. Cooling is by a 3 per cent Sternol soft water emulsion, delivered by a Pulsometer pump, at 900 gallons per minute against a head of 230ft from an 18,000 gallon supply tank; subsequently the warm oil is passed through two Premier forced draught coolers, which can reduce the temperature from 85 deg. to 60 deg. Fah. Three or four passes are made through the mill to reduce the thickness from 2½in to ¾in or ⅝in and the length at this stage may reach 150ft. On the outgoing side a 45ft 6in long table links up with the 196ft long live roller table (by W. H. A. Robertson and Co., Ltd.,) each of the four twenty-five roller sections being driven by a 50 h.p. motor through reduction gearing, line shafts and bevel gears. The table conveys the slab through 18ft long guides to a Head Wrightson upcut shear, which can cut 1in thick hot aluminium plate up to 80in wide. Distant 30ft further along the line is a rotary trimmer, which removes cracked edges and is capable of dealing with hot aluminium slab up to 0·6in thick, the speed of the cutter being synchronised with that of the tables. Two 22ft lengths of live roller tables fitted with guides lead to and away from the trimmer.

The trimmed slab is rolled in one pass down to the gauge required in the final coil in a two-stand tandem four-high hot finishing mill manufactured by W. H. A. Robertson and Co., Ltd., and illustrated on page 321. The stands are 19ft apart and the first stand is distant 320ft from the intermediate mill. Both mills have 24in diameter forged steel work rolls and 56in diameter back rolls, 88in wide, carried in white metal bearings in cast steel chocks, the weight of the rolls being carried by hydraulic rams, a deadweight accumulator loading the system to 1600 lb per square inch. British Thomson-Houston motors power the mills, a 3000 h.p. d.c. motor drives the work rolls of the first stand, giving a speed range of 300ft to 600ft per minute, and a 2600 h.p. d.c. motor operates the second stand rolls through a reduction gear to give a mill speed of 400ft to 800ft per minute. A 10 per cent Sternol soft water emulsion sprayed from banks of flat jets is delivered against a head of 230ft by two 900-gallon per minute Pulsometer pumps from a 18,000-gallon tank and two more pumps move the dirty oil from the 10,000-gallon tank to a Premier cooler, having a 7ft diameter four-bladed fan and capable of 1800 gallons per minute from 85 deg. to 60 deg. Fah. Our illustration shows one of the water coolers. The reduction obtained in the mill may be as much as 80 per cent, giving the final product a length of 600ft, depending upon the final thickness required, the range being from 0·10in to 0·25in.

Leaving the finishing mill, the slab emerges on to a run-out table, 651ft long, containing 218 chromium-plated 0·6 per cent carbon steel tube rollers of 10in diameter by 96in long at 3ft pitch, individually driven by 1 h.p. Laurence Scott induction motors. Water sprays cool the slab to the correct temperature for coiling and it passes through two sets of hydraulic centring pushers on a pair of articulated mechanical guides before reaching a Brookes down-cut shear, 84in wide, which can cut plate up to ¾in thick. After being sheared to length the sheet is edge-trimmed in a machine rated to deal with strip up to 0·2in thick at 800ft per minute and at widths ranging from 24in to 72in.

Completing the hot line is the Wellman Smith Owen three-roll up-coiler. This machine is powered by a 150 h.p. Laurence Scott commutator motor and can coil 0·2in thick strip at 800ft per minute. The finished coils are weighed and then passed to an assembly conveyor from where they are transferred by a special lifting beam to a cooling park before being sent forward for cold rolling.

(To be continued)



EDGE TRIMMER AND COILER

British Transport Commission's Annual Report

THE second annual report of the British Transport Commission shows that during 1949 a deficit of £20·8 million was incurred, despite economies achieved in the face of rising costs. During the year under review the gross receipts from the principal carrying activities of the Commission totalled just over £477,605,000, as against £460,390,000 in 1948; this increase was, however, more than offset by the increase of working expenses from some £424,031,000 in 1948 to £456,217,000 in 1949, and the net traffic receipts therefore fell from about £36,360,000 to £21,389,000. The consolidated balance sheet at the end of the year has a cumulative deficit on net revenue account of nearly £25,500,000 carried forward. The report, discussing the net revenue position, says that a substantial deficit is again inevitable in 1950.

It is pointed out that at present the general level of prices and wages paid by the Commission is double pre-war, and in some cases more than double, but the charges now in force for carrying services are not more on average than 65 per cent above pre-war levels. In part this difference between the level of the Commission's costs and the level of its charges is explained by economies and by increased efficiency of operation, but much of it is attributable to the favourable load factors at present enjoyed by the various transport systems as compared with pre-war. Meanwhile prices continue their upward trend almost without pause and often with little warning. By contrast the charges made by the Commission for the bulk of the transport services can only be altered after formal and public hearings, and experience has shown that deficiencies of revenue can amount to a serious sum before the balance is restored.

The report states that considerable economies were achieved in the face of rising costs. Wage and price increases during 1949 raised the Commission's expenditure by some £11 million. There were increases in the price of coal and steel, and, after devaluation last September, in other commodities. Concessions granted to the staff alone in 1949 will cost £2·2 million in a full year. At the same time, staff and other economies attained on the railways amounted to £6½ million, and the cost of increased engine and wagon mileage and net ton-miles carried totalled over a million pounds. The net increase in railway expenditure, which, it is noted, accounts for about 64 per cent of the total working expenses of the Commission, was thus kept down to £3 million, or only 1 per cent over 1948. Railway staff reductions in 1949 totalled 23,151, and the saving on wages, including economy in the use of overtime, was nearly £5 million. About a million pounds was saved in compensation for goods lost and damaged, and £600,000 by economy in coal consumption, but the increased price of coal represented an extra cost of roughly a million pounds.

A decline in the receipts of the carrying services in 1949, compared with 1948, was due chiefly to a fall of £10,600,000 on British Railways and a million pounds on London Transport. The proportion of receipts from concession rates, such as workmen's, season and cheap day tickets, rose in 1949 from 19 per cent to 25 per cent, resulting in an average fare per mile of about 1¼d. per mile (all classes), compared with the statutory maximum of 2·44d. per mile (third class). There is no standard structure of bus fares outside London, but the charges per passenger-mile in 1949 were estimated to vary from ½d. to 1¾d.

Dealing with development work in 1949, the report points out that this work included the completion of certain pre-war schemes which had been suspended during the war, such as the opening of the Liverpool Street to Shenfield electrification and the Central Line extension to Epping; and considerable progress was made in replacing over-age vehicles in the London Transport omnibus fleet.

In most other directions, states the Commission, it has been possible to do little more than keep pace with current maintenance and to overtake to a modest extent some of the wartime arrears. Strict Government control over the allocations of steel to the railways resulted in an allocation of 810,000 tons against estimated requirements for 1949 of about 1,000,000 tons. This reduction fell with particular severity upon the wagon building programme and the change to the modern all-steel mineral wagon. Development is also subject to the Government control of capital investment. Notwithstanding representations by the Commission that any reduction might have serious consequences upon the efficiency of the railways, the approved level of railway expenditure in 1950 was reduced from £100 million to £92 million. Some alleviation has since been obtained by the approval of a special wagon programme costing £2·7 million.

Following completion of the new Ocean Terminal at Southampton, a new terminal for the Union Castle Line at the same port has been approved. The Commission has agreed that a detailed scheme for the electrification of the London, Tilbury and Southend section shall be prepared, preliminary surveys of which are in hand.

Four and Six Spindle Automatics

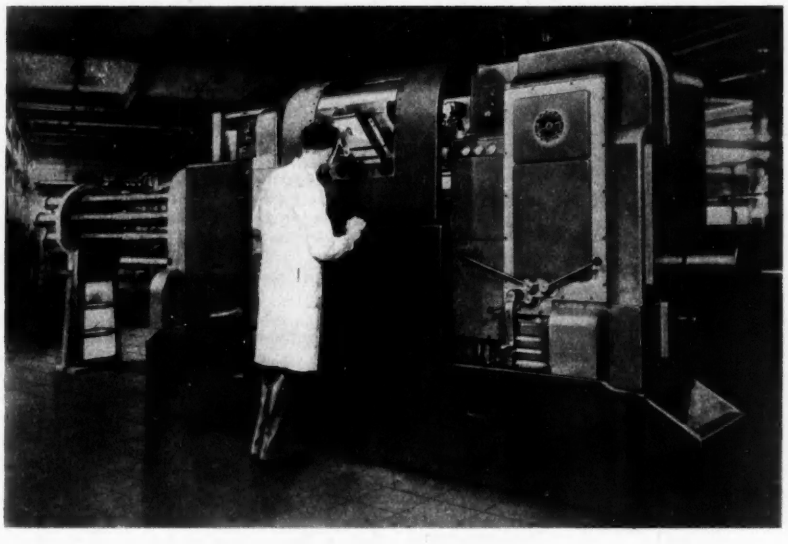
THE range of multi-spindle bar automatics made by A. C. Wickman, Ltd., of Coventry, has been extended by the addition of two new machines, one with four spindles of 3½in capacity and one with six spindles of 2½in capacity. The new machines follow closely the lines of the company's five-spindle automatics, but are of heavier construction and embody a number of improvements.

We reproduce a photograph of one of the new automatics and the leading particulars of the two machines are as follows :—

	Six-spindle	Four-spindle
Maximum bar diameter	2½in	3½in
Maximum bar feed	10in	10in
Feed stroke on main tool block	0–5in	0–5in
Feed stroke on fourth and fifth slides	0–5½in	—
Feed stroke on third slide	—	0–5½in
Feed stroke on fourth slide	—	0–3½in
Standard idle stroke to end-working slides	3½in	3½in
Special idle stroke to end-working slides	5in	5in
Maximum length turned with standard idle stroke cam	9in	9in
Lower cross slides idle stroke	1½in min.	1½in min.
Lower cross slides feed stroke	0–1½in	0–1½in
Upper cross slides idle stroke	1½in	1½in
Upper cross slides feed stroke	0–2½in	0–2½in
Auxiliary cross slides idle stroke	1½in	—
Auxiliary cross slides feed stroke	½–1½in	—
Spindle speed range in twenty-four steps	80–1000	60–800
Range of cycle time in seconds	7·1–922	7·1–922
Idle time—tool return, index, tool approach	3 sec.	3 sec.
Motor horsepower, maximum	40	40
Motor speed	1425	1425

Each of the new machines incorporates the maker's well-known design of setting mechanism, by which simple sliding adjustments on graduated scales effect alterations to the longitudinal and cross slide working strokes and bar feed, without necessity for changing cams.

The main frame has been designed and built to provide a heavy rigid unit which will be free from vibration when the machine is operating with heavy cutting loads. This frame comprises the base and chip pan and drum and drive housings rigidly bolted together, and has a heavy beam connecting the two housings to form a closed frame of exceptional stiffness. The large open pan is heavily ribbed underneath and provides ample coolant and chip space.



MULTI-SPINDLE AUTOMATIC

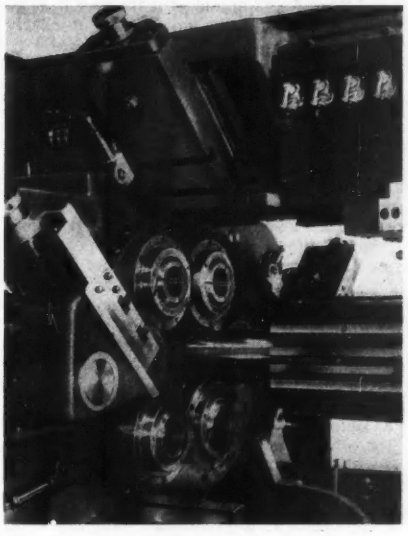
A protected motor of up to 40 h.p. used to drive the machine is mounted on a hinged platform at the rear and drives the constant-speed shaft through heavy vee belts. From the constant-speed shaft a second shaft is driven through a range of gears to provide high and low spindle speeds, individual speeds being obtained by use of pick-off gears. Also taken from the constant-speed shaft are the drives for the coolant and oil pumps and the high-speed clutch, which is engaged during all non-productive movements of the machine. A central shaft passing through to the spindle drum drives the spindles.

From the central shaft is also operated the feed drive for controlling the production cycle time, as well as various standard and special end-working attachments. This feed drive consists of a primary reduction, two pairs of pick-off gears for varying the cycle time, a safety clutch, and a roller type overrun clutch incorporated in the slow side of the fast and slow clutch, which controls the non-productive and productive portions of the cycle of operations. The drive is transmitted through a safety clutch and a power feed clutch, which incorporates a brake and is interlocked with a hand winding mechanism. The two safety clutches are rated to protect the mechanism of the machine during feed and fast motion operations. All of the speed and feed gears are of heat-treated alloy steel and the speed drive gears are profile ground. Worms are of nickel steel case-hardened and ground, and the worm wheels are made of centrifugally cast phosphor-bronze. All of the sliding gears in the feed drive are mounted on splined shafts and the pick-off gears are keyed on taper shafts.

In the spindle drum high-tensile steel spindles are mounted on precision pre-loaded anti-friction taper bearings and are fitted with collet seatings. A spool on each spindle operates drawback collets through fingers and springs designed to compensate for bars of varying size. The cast iron spindle drum is positioned by hardened locator pieces at every index and these locator pieces are ground to a maximum permitted tolerance of 0·0002in for spacing. The maker's manufacturing specification calls for the bores for the spindle bearings to be equally spaced to one another and to the centre bore and outside diameter to within plus or minus 0·0002in, and for the collet seatings to run true within 0·0005in.

The drum is indexed through gears by a modified Maltese cross mechanism and at each cycle the drum is indexed slightly past its correct position before being drawn back by a toggle clamp on to the locators. This arrangement has been adopted to obviate wear in the locating gear and assure the maintenance of indexing accuracy. To enable repeated trial cuts to be made at individual stations when setting up a special clutch is provided and it can be used to disengage the drum indexing, bar feed, collet operating and drum locking mechanisms. At the front of the spindle drum is a stop ring with individual stop screws for each spindle to correct small sizing errors

The bar feeding slide stroke is controlled by a cam set directly below the slide ; two cams



TOOLING AREA—SIX SPINDLE AUTOMATIC

cover the full length of feed range, and bars are fed forwards by powerful adjustable springs. Collet operation is direct from the cam to a slide ; hand operation is also provided.

The main camshaft extends from the worm wheel in the drive housing through the drum housing to the stock carriage end of the machine. On this shaft are set the cams for cross slide feed and approach stroke, bar feed and collet operation, spindle drum locking, and the arm of the Maltese cross mechanism and indexing clutch. A cam drum fitted in the attachment drive housing can be used for carrying cams for special end-working attachments, and a cam disc in the drum housing enables cams to be fitted for varying independently the movements of the cross slides or cross slide attachments. An upper camshaft, transversely mounted across the top of the drive housing, carries disc cams for operating the end-working slides and attachments, the dogs controlling the fast slow clutch, and a timing dial used to indicate the timing of all the machine movements.

Two lower and two upper cross slides are provided on both the four and the six-spindle machines. On the six-spindle machine, however, an additional cross slide is used for parting-off at the front and a further auxiliary cross slide can be fitted in station 3, if required. All of the cross slides are provided with means of micrometer adjustment and, other than the part-off slide, all have master stops against the individual stop screws in the spindle drum stop ring for size controlling purposes. Each of these slides has a virtually constant approach stroke and an infinitely adjustable feed stroke.

The central main tool slide moves on a large-diameter central stem and all torque is taken by the guide arm. The mechanism actuating this slide provides a constant approach stroke together with an infinitely variable feed stroke.

The mechanism controlling the movement of the main tool slide and the two auxiliary slides, when fitted, is mounted above the drive housing. Through the fixed cams and quadrant linkage mechanism carried on the transversely mounted camshaft, rapid and accurate setting of the feed strokes for end-working tools is effected by the sliding of setting blocks along graduated scales on the quadrants. The centre block and auxiliary slides are actuated by pusher racks, to which the motion of the quadrants is transmitted by means of racks and pinions. Each of the cross slides is controlled by a similar mechanism, adjustments to feed strokes being effected by movement of sliding blocks on quadrants.

Metallurgical Topics

Vanadium-Treated Deep-Drawing Steel

For many years it has been customary to use sheets rolled from rimming steel ingots for deep-drawing operations. One of the main advantages of rimming steel is its good surface quality ensured by the outer skin of nearly pure iron which envelops the ingot. Ordinary rimming steel, however, has the serious disadvantage of being subject to ageing during storage. Such ageing may show itself in different ways; it may result in increased hardness and brittleness, reduced drawability and the formation of stretcher strain markings in the drawn component. Stretcher strain markings may occur in any steel which shows a pronounced yield point. They may be avoided if the sheet is pressed immediately after temper-rolling or a "skin pass." This treatment has the effect of eliminating the "kink" at the yield point, and gives sheet having a smooth stress-strain curve. Material giving this type of curve is likely to be free from stretcher strain markings. One aspect of the ageing of rimming steels is that the effect of temper-rolling passes away after a short period of storage, and extension at a definite yield point returns.

To obviate ageing aluminium-killed steel was widely employed, and came into use to a limited extent for deep drawing. This steel, killed by the addition of 4 lb to 5 lb of aluminium per ton, is non-ageing and has good drawing properties; but the surface of aluminium-killed steel sheet is not so good as that of a rimming steel sheet. Surface defects caused by alumina inclusions may not only mar the appearance of the drawn product, but may also be the cause of breakage in the drawing operation.

It has been reported by S. Epstein, H. J. Cutler and J. W. Frame* that the addition of 0·05 per cent of vanadium (1 lb per ton in the ladle) renders the steel non-ageing without "killing" it, as it does not deoxidise the steel enough to affect the rimming action. In Figs. 1 and 2 are reproduced load-extension diagrams of ordinary and vanadium-treated rimming steels showing the return of the yield point on ageing the ordinary rimming steel and the absence of this evidence of ageing in the vanadium-treated steel.

A typical analysis of the vanadium-treated steel is:

	Per cent
Carbon	0·05
Manganese	0·29
Sulphur	0·030
Vanadium	0·044

and it shows the following properties:—

Yield point, tons per square inch	12·5
Tensile strength	19·9
Elongation, per cent on 2in	42

The steel shows slight strain-hardening (Fig. 2), but no further hardening on ageing. It is also free from "blue brittleness," as indicated by the fact that its tensile strength does not increase at 400 deg. Fah. (204 deg. Cent.), but shows a decrease, compared with its tensile strength at room temperature, of from 3·7 to 4·8 tons per square inch, while ordinary rimming steel showed an increase of 5·8 tons per square inch.

More detail will presumably be available about this steel in the future. It would be interesting to know whether the vanadium, with its strong affinity for nitrogen, is sufficient in amount to suppress age-embrittlement in this steel while permitting it to retain the characteristics of a rimming steel.

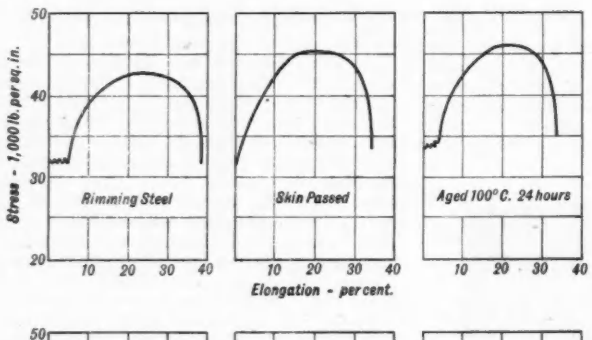


Fig. 1—*Load-Extension Diagrams of Ordinary Rimming Steel Before and After Ageing.*

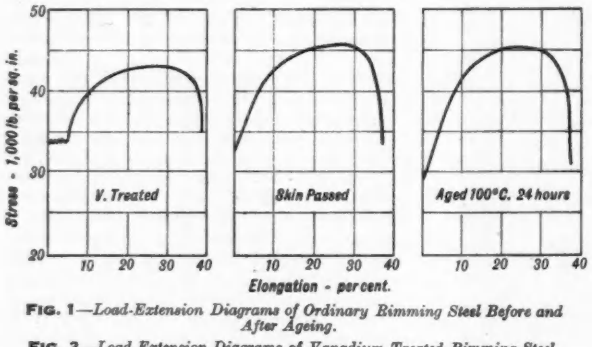


Fig. 2—*Load-Extension Diagrams of Vanadium-Treated Rimming Steel Before and After Ageing*

* *Journal of Metals*, June, 1950, page 830.

Chromising

A new chromising process—or coating with chromium by a method which involves heating to a high temperature as opposed to the electro-deposition process—has recently been suggested by P. Galmiche.[1] In one form or another the chromising process has attracted attention for over twenty-five years. Proposals for the production of chromium-rich protective coatings on steel by a "cementation" method, analogous to the carburising process for obtaining a high carbon case on a mild steel article, were first put forward by F. C. Kelly[2] in 1923. The articles were loosely packed in a drum with a mixture of chromium (or ferro-chromium) powder and alumina (which acted as a diluent), and were heated in an atmosphere of hydrogen at a temperature of 1300 deg. to 1400 deg. Cent. The effect of time, temperature and composition of the steel and of the cementing material were studied by J. Laissus.[3] The best results were obtained with a high temperature and a low carbon content, both in the steel and in the chromising mixture. Chromium powder with less than its weight of aluminium gave a layer which, while thinner than that produced by ferro-chromium, was more adherent. The chromium in the surface layer of an iron bar embedded in chromium powder and heated in hydrogen increased with increase in temperature and time of treatment from 5 per cent after twenty-four hours at 1100 deg. Cent. to 53 per cent after ninety-six hours at 1320 deg. Cent.[4] In commercial practice four hours at 1300 deg. Cent. was claimed to give a coating 0·01in thick with a chromium content of 10 to 20 per cent. In the first attempt to use chromium oxide (which would be reduced to chromium by the action of the hydrogen) in place of metallic chromium the oxide tended to sinter and leave bare spots on the iron.[5] Repeated powdering and redistribution of the powder was necessary to correct this defect. A more successful use of chromium oxide was made in the Follsain process,[6] in which the steel and iron specimens were packed in a mixture of aluminium, chromium oxide and carborundum (which acted as a diluent) and subjected to a temperature of 850 deg. to 1000 deg. Cent. for upwards of three hours. An alumino-thermic reaction then took place with the production of a cemented layer of high chromium content. In these methods the chromium in the chromising medium is present in the solid form. The surfaces produced from the solid mixtures tend to be rough and irregular, but they show high resistance to oxidation and corrosion by hot gases and to attack by nitric acid. Before liquid and gaseous chromising media, which give better surfaces, are considered, mentioned may be made of the proposal to apply a diffusion treatment at 1100 deg. to 1300 deg. Cent. to chromium, deposited electrolytically on nickel, to give a chromium-rich, nickel-chromium alloy bonded to the steel through a nickel-rich, iron-nickel layer.

In chromising by means of a liquid medium the metal to be treated is immersed in a salt bath containing chromium chloride and an indifferent diluent, such as barium chloride, at a temperature of 1100 deg. to 1200 deg. Cent.[7] The amount of chromium which diffuses into the iron can be adjusted as desired either by changing the composition of the bath or the $CrCl_3/CrCl_2$ ratio, or by adding vanadium chloride.

In the gas process chromium chloride vapour is used. It is generally formed by the passage of hydrogen charged with hydrochloric acid over chromium or ferro-chromium, and is absorbed in a porous ceramic material in which the steel to be treated is packed and heated.[8] In four hours at 1000 deg. Cent. it gives an altered layer of thickness 0·15mm containing 35 per cent of chromium at the surface and 8 per cent at a depth of 0·1mm.[9] The chromium penetrates to a uniform depth even on the inside of small holes. A low-carbon steel is essential; in high-carbon steels carbon diffuses towards the outside and forms a layer of chromium carbide which impedes the diffusion of chromium. In Germany, special chromising steels have been developed—the "IK" (i.e., "Inkromierung") steels—containing elements, such as titanium, capable of fixing the carbon.[10]

The New Fluoride Process

In the process described by P. Galmiche[1] the steel articles are placed in a mixture of 30 to 60 per cent of chromium powder, 3 to 10 per cent of ammonium fluoride and the remainder alumina or kaolin, while more chromium is placed in an additional container. The whole is heated to 900 deg. to 1200 deg. Cent. The chromium fluoride formed is decomposed by hydrogen at the surface of the steel, forming chromium which is deposited on the surface and hydrofluoric acid which forms more fluoride with the chromium container, thus acting as a carrier for the chromium. On 0·1 per cent carbon steel a layer 0·1mm thick is formed in three hours at 1000 deg. Cent., and one of 0·25mm thick in six hours at 1100 deg. Cent. Only a much thinner case can be produced on a 0·4 per cent carbon steel. The coatings on 0·1 per cent carbon steel are in the form of solid solutions and have a hardness approximating to that of the underlying metal. The chromium content of the extreme surface layer reaches 50 or 60 per cent; it falls off quickly at first and then more slowly to 15 per cent, then more rapidly again until the composition of the underlying steel is approached. On 0·4 per cent carbon steel or on cast iron a layer of chromium carbide separates the steel from the high chromium surface. Its hardness is great, but penetration is small. To get deep penetration in high carbon steels they must first be decarburised by heating in moist hydrogen at 900 deg. to 1000 deg. Cent. Hardness is thus sacrificed. On the other hand, if great hardness is required the initially high hardness of the carbon steel after chromising may be increased to over 1700 by nitriding. Typical hardness values are given in Table I.

The altered layer of the steel may simultaneously be alloyed with aluminium or silicon

by adding these elements to the mixture in which the steel is embedded. About 5 per cent of aluminium added to the mixture, heated

TABLE I—*Vickers Diamond Hardness of Surface Layers*

0·1 per cent carbon, 0·1mm thick		0·4 per cent carbon, 0·04mm thick	
Distance from surface, μ	Hardness (30kg)	Distance from surface, μ	Hardness (30kg)
0	940	0	1250
26	230	11	910
44	230	19	890
61	240	37	930
97	178	45	188
127	147	125	151

at 1000 deg. Cent. for one hour, produces a 0·2mm thick coating containing 10 to 12 per cent aluminium and 4 to 5 per cent chromium. With 10 per cent of aluminium and heating for four hours at 1000 deg. Cent. a case 0·8mm thick is produced having 15 per cent aluminium and 2·5 per cent chromium. With 2·5 per cent of aluminium a ductile case is produced, and with 2·5 per cent of silicon a relatively flexible coating 0·25mm thick is obtained after two hours at 1000 deg. Cent.

Trials were carried out to determine the resistance of the coatings to corrosion by hot gases and to oxidation, the progress being followed by weight measurements and micro-examination. Up to 850 deg. Cent. the resistance to gases of combustion of layers of different thicknesses was excellent and comparable with that of the best heat-resisting steels. At 900 deg. Cent. a separation of the curves of corrosion for the two thicknesses, 0·1mm and 0·25mm, was observed, and at 1000 deg. Cent. the 0·1mm layer had very little protective effect. The addition of 1 per cent of sulphur dioxide to the gas caused no great increase in corrosion. The coatings showed a good resistance to thermal shock.

Nickel and nickel-base alloys may be coated by this process. Some of these alloys have good mechanical properties at high temperatures, but relatively poor resistance to corrosion by hot gases. After chromising they present good resistance up to 900 deg. Cent. Molybdenum and tungsten are much more difficult to treat on account of the slow rate of diffusion of chromium into these metals. It takes three hours at 1300 deg. Cent. to produce a layer 0·02mm deep.

Chromising is a relatively expensive process of limited application, and it may be surmised that practical difficulties in dealing with hydrofluoric acid at the temperatures involved must be considerable, and may outweigh the apparent advantages in speed and reduced temperature of operation. There would appear, however, to be a useful future for the method of chromium coating from a vapour phase which may be applied to relatively inexpensive material in the form of machined parts containing holes and recesses or components of welded construction and confer on them good resistance to scaling and to the action of high-temperature products of combustion.

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Young's Modulus at High Temperatures

Two papers, having a bearing on this subject, have appeared in a recent number of *Metal Progress*. In a general article on "The Modulus of Elasticity," J. E. Dorn and T. E. Tietz[1] have reviewed the metallurgical factors which affect the modulus in the light of papers published by W. Köster[2] since the last critical review of the subject by D. J. Mack[3]. Although the modulus of elasticity of a metal is rather insensitive to most metallurgical variables, alloying elements may have a considerable effect. As a rule, however, the effect is of

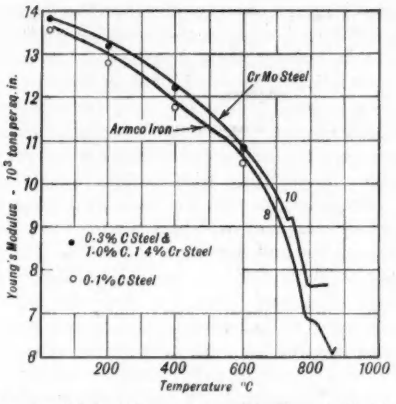

FIG. 1—*Effect of Temperature on the Young's Modulus of Armco Iron and Chromium-Molybdenum Steel (Andrew's Nos. 8 and 10. Individual points for other steels are taken from Roberts and Nortcliffe, and Jones and Nortcliffe.)*

little practical value, as any substantial change in the modulus from that of the basis metal is associated with undesirable mechanical properties in other respects.

Variations in temperature are of much greater importance, and certain generalisations have been suggested to express the behaviour of metals and alloys. Thus, Köster found that the modulus at a given temperature plotted against the ratio of that temperature to the melting point (both on the absolute scale) showed an almost linear relationship for a wide range of temperature.

Jones and Nortcliffe[4] were able to show, both from their own results and from those of Roberts and Nortcliffe, that the modulus of any ferritic steel at a high temperature was a constant fraction of its modulus at room temperature. Similarly, the modulus of certain austenitic steels at a given temperature was a constant fraction of the value at room temperature. The fractions in this case were slightly smaller than for the ferritic steels and bore a linear relationship to the temperature: the differences between calculated and experimental values were, however, greater than for ferritic steels.

Measurements of the modulus of elasticity of a variety of materials have been carefully made by C. W. Andrews[5]. The method used—a dynamic method—was the same as that used by Roberts and Nortcliffe, and the materials included Armco iron, chromium-molybdenum steel, several types of austenitic steel, Inconel, Stellite and an aluminium alloy. The results were reported graphically in curves of modulus (in pounds per square inch) against temperature in deg. Fah. Those reproduced in Figs. 1 and 2 have been transposed into tons per square inch and deg. Cent. to afford more ready comparison with the results of Nortcliffe and his collaborators. Compositions were not the same in the two series of tests, but good agreement was shown between Andrews' results for Armco iron and those of Roberts and Nortcliffe for 0·1 per cent carbon steel; also between Andrews' chromium-molybdenum steel and both the 0·3 per cent carbon and the 1 per cent chromium (En 31) steels of the British investigators (Fig. 1). The factors deduced by Jones and Nortcliffe for ferritic steels applied with a considerable degree of accuracy to the results of Andrews, and the same applies with a somewhat wider variation between actual and calculated results to some of the austenitic steels. A comparison between actual and calculated results is given in Tables I and II. A curious feature shown by Andrews' steel No. 4 (chromium 19, nickel 10, carbon 0·07, columbium 1 per cent; cold-rolled sheet)

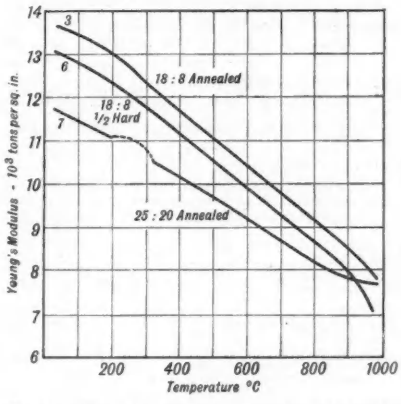

FIG. 2—*Effect of Temperature on the Young's Modulus of Austenitic Chromium-Nickel Steels (Andrews' Nos. 3, 6 and 7).*

was the marked difference between the longitudinal and transverse modulus. In tons per square inch and deg. Cent. the values were:—

Longitudinal ... ... 12000−4(*t*−20)
Transverse ... ... 13700−5(*t*−20)

It would appear that the value was affected by internal stress in the longitudinal direction. The values converged at high temperatures and both showed a rapid decrease at about 800 deg. Cent., owing to softening and decreased resistance to creep.

Mention may also be made of the results on the aluminium alloy containing zinc 5·5, copper 1·5, magnesium 2·5, chromium 0·3 and manganese 0·2 per cent. This gave, both in sheet and bar, results very similar to Köster's values for aluminium, all of which approximated closely to the value: 10·5−0·0067 (*t*−20) million lb per square inch.

TABLE I—*Temperature Variation of the Young's Modulus of Ferritic Steels, in Thousand Tons per Square Inch. (Calculated Values in Brackets.)*

Temperature deg. Cent.	Jones and Nortcliffe's Factor	Armco Iron	Cr-Mo Steel C 0·31, Cr 1·0, Mo 0·21
20	1·0	13·5	13·7
200	0·948	12·9 (12·8)	13·2 (13·0)
400	0·875	11·8 (11·8)	12·2 (12·0)
600	0·775	10·5 (10·5)	10·8 (10·6)

TABLE II—*Temperature Variation of the Young's Modulus of Austenitic Steels in Thousand Tons per Square Inch. (Calculated Values in Brackets.)*

Temperature, deg. Cent.	Jones and Nortcliffe's Factor	18 : 8 Type Annealed C 0·07 Cr 19 Ni 9	18 : 8 Type Cold-drawn, ½ hard bar C 0·12 Cr 18 Ni 9	25 : 20 Type Annealed C 0·20 Cr 25 Ni 20
20	1·0	13·7	13·0	11·7
200	0·930	12·9 (12·7)	12·4 (12·1)	11·0 (10·9)
400	0·845	11·7 (11·6)	11·1 (11·0)	10·2 (9·9)
600	0·762	10·5 (10·5)	9·9 (9·9)	9·2 (8·9)
800	0·680	9·2 (9·3)	8·7 (8·8)	8·3 (7·9)

Mention may also be made of the results on the aluminium alloy containing zinc 5·5, copper 1·5, magnesium 2·5, chromium 0·3 and manganese 0·2 per cent. This gave, both in sheet and bar, results very similar to Köster's values for aluminium, all of which approximated closely to the value: 10·5−0·0067 (*t*−20) million lb per square inch.

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THE TRAINING OF CRAFTSMEN

IN our issue of September 1st, in our "Productivity in British Industry" series, we printed an article by Mr. Vincent Everard on "The Importance of the Craftsman." Just after that issue had gone to press and unfortunately just when the recent dispute in the printing trade made it impossible for us adequately to refer to it immediately, there was issued by the Parliamentary and Scientific Committee a report entitled "Technical Education and Skilled Manpower." In more formal terms that report echoes the views of Mr. Everard. "In this country," it is remarked, "we have largely failed in recent decades to maintain the high regard in which the craftsman was once held. Strong evidence of that is found in the fact that he is paid little more than the unskilled worker. Much improvement must be effected if in this country the dignity and respect formerly accorded to craft employment are to be regained."

How necessary it is that the importance of the craftsman should be appreciated was well emphasised by Mr. Everard in the article to which we have already referred. "All the semi-skilled operatives in the mass-production factories are dependent upon . . . the craftsman-built generating station, upon the multi-process complicated automatic and semi-automatic machine tools. If those craftsmen are not there in twenty-five years' time those machines will not be built and there will not be the jobs for the 'easy-money boys' of the mass-production trades." In this century there has been a growing appreciation of the need for more technically trained men in industry and, even before the war came to reveal how short was industry of such men, apprentices entering industry could, under the wise training schemes operated by many engineering firms, attend evening classes or even part-time at the local technical college. There they could take courses for the Ordinary and Higher National Certificates and hope by that means to become, eventually, fully qualified engineers. Since the war the path of possible advance has been widened and a greater number of the more able students can even expect, if they so desire it, to complete their technical education at a university. Such a prospective route for promotion is, of course, very attractive to apprentices. But unfortunately it is a route that leads away from craftsmanship to those "white-collar" jobs that have attained a higher social status. It is possible that it has become too attractive. Certainly the Parliamentary and Scientific Committee thinks that it has. For its report remarks that "there is a tendency for many apprentices and other young workers, particularly in the engineering and building industries, to embark on a National Certificate course although they would gain far more benefit from a course leading to the award of a City and Guilds Craft Certificate," and it feels it desirable, therefore, to offer some suggestions that might increase the attraction of a career in craftsmanship. For instance, "consideration might be given to an expansion in craft certification in order to create a nation-wide system of certification which would be acceptable to those controlling conditions of employment and would undoubtedly give an added incentive to those studying for awards." On another tack it is suggested that "there is considerable room for improvement in the teaching in . . . Works Schools, and consideration might well be given to the setting up of a course for training the Education Officers of industrial firms." Those are valuable suggestions. But there are two difficulties in particular to be overcome. There is, first, the fact that a youngster entering industry is likely to see that he can very soon earn high pay in a semi-skilled job, whereas to become skilled he must endure a long and lowly paid apprenticeship and attain at the end of it little more security of employment and little, if any, higher pay. And secondly, there is the fact that in the capital goods factory the wages of the craftsmen must account for a very much higher proportion of total costs than do the wages of the semi-skilled in the mass-production concern. Thus there is imposed a limit upon the amount that a craftsman can expect to be paid. If, then, there is an answer to the problem, it must lie in making craftsmanship, if not better paid, at least more attractive in other ways.

Our need to-day, it seems to us, is for craftsmen differing in certain respects from the skilled hand of the past. For the craftsman is coming to occupy a new position. To quote from the Committee's report, "the skilled man is an essential link in the chain between scientific discoveries and their translation into industrial practice." The craftsman of to-morrow will need a trained intelligence besides inherited aptitude and skill of hand. He must be willing to welcome and to initiate rather than to resist changes, to co-operate with rather than to oppose research workers. His skill needs to be based less upon traditions learnt from his fathers than upon a fuller understanding of the operations he performs. He needs, therefore, both to be trained to play such a part in industry and to be given the status within industry—a status, surely, little less important than that of junior staff—that should go with it. In 1943 the Institution of Mechanical Engineers held a short symposium of papers upon the training of engineers. One of the papers, contributed by Dr. Fisher, contained some paragraphs on craft training in which the remark appeared that "to secure any considerable increase in craft training a new deliberate policy of encouragement must be adopted." Those paragraphs attracted little attention. The bulk of those who contributed to the discussion of the papers confined their comments to their views on the technical education of engineers. But that lack of interest is now far less apparent and we are glad to note that in its coming winter session that Institution is to discuss a paper by Mr. Loxham on the "Training of Craftsmen." We shall look forward to reporting that discussion and we hope that this winter that Institution will not be alone in giving attention to the subject.

PRODUCTIVITY AND OTHER STUDIES

THE speech made by Sir Geoffrey Heyworth on the occasion of the recent annual general meeting of Lever Brothers and Unilever, Ltd., contains matter not likely to be overlooked by engineers. That it will be stimulating to manufacturers everywhere is certain, since from the time of Sir Richard Arkwright—whose labours may almost be said to have inaugurated the factory system—the subject of productivity has been of great importance to the community. Indeed, Sir Geoffrey Heyworth's speech shows how great has been the development of thought and activity on this subject since those days in 1771 when Arkwright (who had commenced life as a barber and hairdresser) established the first cotton mill in the world. That was 180 years ago. Since then a great part of the entire world has become more or less industrialised, a process attended by all manner of economic, social and political turbulence, never more acute than at the present moment. It is, accordingly, very helpful when a prominent leader of industry gives public and frank expression to his views, and it is specially helpful when those views are backed by concrete evidence from industry itself. For example, after pointing out that "wherever individual performance is inadequate, it is wise to look at the methods of supervision," Sir Geoffrey goes on to state that "In our experience a good manager's efforts to increase efficiency, after mutual consultation, are hardly ever frustrated by resistance from the workers. Neither workers nor office personnel like to work long hours but, whilst they are on the job, they are generally willing

to work. We are always in a position to compare conditions in different countries, and it is remarkable—perhaps to many this may be unexpected—that in our experience of European countries we have not found any important differences between the workers of various nationalities as far as willingness to work and potential performance are concerned."

It is necessary, of course, to discriminate between different kinds of industry, since individual industries have problems peculiar to themselves. The broad distinction—as it seems to us—is between industries employing large numbers of craftsmen and those in which the proportion of craftsmen in the total number of people employed is small. We cannot deal with a heavy engineering or metallurgical industry in the same way as we might be able to deal with industries such as those specifically referred to by Sir Geoffrey Heyworth. To control the operation of soap packaging and other such machines is a very different matter from melting and forging steel, winding a large turbo-alternator or machining and blading the rotor body of the turbine. In the type of factory covered by the admirable speech to which we are referring the craftsman element is represented by maintenance workers, and Sir Geoffrey points out that "there are some operations in a factory which do not lend themselves readily to inclusion in incentive schemes based on the output of the operators immediately concerned—maintenance workers being a good example. The difficulty with these non-standard work tasks is to measure them satisfactorily and record them without excessive cost." There are, however, other difficulties with these non-standard tasks than is presented by their satisfactory and economical "measurement." What is specially precious in a craftsman is of much smaller value in a person who operates as a unit in a mechanised system where productivity (in the sense of physical volume) is the major target. In the engineering industry there is clamant need for initiative (defined as "the habit of doing things without being told") and judgment, defined, by the same American commentator, as "a good batting average in your guesses." While the value of production studies is well shown by the facts quoted by Sir Geoffrey Heyworth, it seems to us that in engineering works we shall always be peculiarly dependent upon the training and quality of the individual man and the character of the leadership which he gets. While doing all that is possible to "streamline" production, we must encourage recognition of the status of the craftsman. It is true, of course, that modern equipment has effected great changes, as, for example, in the provision of such items as jig boring machines, profiling machines, grinding machines, &c., which, in the hands of semi-skilled men are able to perform, with extraordinary accuracy, work which hitherto demanded the highly polished skill of the expert toolmaker. But even with all these machines the craftsman is, as was recently declared at the Birmingham meeting of the Institution of Mechanical Engineers, the backbone of the engineering industry.

Long ago Auguste Comte remarked that "If we have been accustomed to deplore the spectacle, among the artisan class, of a workman occupied during his whole life in nothing but making knife handles or pinheads, we may find something quite as lamentable in the intellectual class, in the exclusive employment of the human brain in resolving equations or classifying insects. The moral effect is unhappily analogous in both cases. It occasions a miserable indifference about the general course of human affairs as long as there are equations to resolve or pins to manufacture." This is a condition which we have constantly to keep in mind, since no matter to what degree of perfection it may be possible to carry production studies and regardless of the success reached in securing harmony between management and worker, we have to deal not only with the development of the man himself, but with those influences which surround him during that major fraction of his time which he disposes of as he thinks best. We have been told—on high authority—that "increase in amount and reduction in cost of production are socially useless unless they conduce to hygienic, cultural and ethical progress—the advancement of the physical, mental and moral welfare of the community and of entire humanity." Surely this is something which must be placed increasingly in the foreground as part of any comprehensive planning by industrialists, since valuable as production studies certainly are, they do not represent other than a partial solution. "Above all," remarks Sir Geoffrey Heyworth, "the first priority must be given to the maintenance of complete confidence between management and workers." This confidence will surely be best promoted where there is a realisation that industry is part of life.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

SOME AMERICAN LOCOMOTIVES AND THEIR RUNNING

SIR,—A number of points of interest arise from the recent article on "American Locomotives and Their Running."

Referring to the suggestion that engines with roller bearings are more liable to slip, should not the statement be qualified by adding "at a given regulator opening and under comparable conditions?" the explanation being, presumably, that as less power is consumed by internal friction more is available at the driving wheels.

With regard to the accidents to which the round house and its turntable are prone, it is surprising that each "road" is not protected by a derailer which can only be removed when the turntable is properly aligned with and locked to the "road" to be used.

One remarkable statement is made in connection with the notes on mechanical stokers.

It is not difficult to understand that a thin fire may rapidly die out when the feed is cut off, but it seems incredible that an "almost dead fire is brought back to nearly full intensity by less than a minute's application of the stoker." The stoker has first to cover the grate evenly with green coal and then the whole 96 square feet has to burst into flame at nearly "full intensity," all in less than one minute! Presumably it all depends upon the definition of "almost dead" as applied to a fire.

It is interesting—and most surprising—to learn that American locomotives are not fitted with hand brakes and that a length of chain is laid each side of a wheel to prevent runaway when a dead engine is left standing. What is the explanation of this omission? Is there any explanation? How and why can a simple hand brake be omitted from 300-ton engines fitted with mechanical stokers, electric head lamps, cab lighting—and train-control equipment?

Is it possible for the author of the article to give sectional drawings of the cylinders of the 4–8–4 engines fitted with Franklin cam-operated poppet valves? With twin 5in inlet and 6in exhaust valves at each end of a cylinder surely there is an excessive clearance volume which must detract from the efficiency of the steam distribution system. Drawings showing the lay-out of the valves would be of great interest. It is not clear why any cam-operated valve should be operated by a link motion, and these engines are said to have four sets of Walschaert gear. Unnecessary complications seem to be inevitable with such a system with its numerous pin joints.

The "Niagara" engines fitted with twin 6½in inlet and triple 6in exhaust poppet valves (presumably double-beat valves) at each end of each cylinder must have abnormal clearance volume, and the flow of steam through the inlet and exhaust valves must be far more turbulent than would be the case with piston valves of equivalent capacity. The author states that the piston thrusts of these engines could be felt for the first few revolutions from rest when pulling hard. This is not surprising in view of the dimension of the cylinders. The comparatively "toy" tank engines of Great Western design give rise to real discomfort when starting quite light trains and the piston thrusts can be felt until some considerable speed is attained.

The author is to be congratulated upon so successfully combining business with pleasure and for recording his experiences for the benefit of less fortunate enthusiasts who can never expect to have such opportunities for footplate travel.

E. B. PARKER

Wirral, September 16th.

RECENT DEVELOPMENTS IN LIGHT-WEIGHT SPARK IGNITION AND COMPRESSION IGNITION PISTON ENGINES

SIR,—In your issue of July 28th, on page 104, there is a précis of a paper which I wrote recently for the Fourth World Power Conference.

One of the main points which I attempted to make in the diesel section of this paper was that the two-stroke engine no longer leads in power/weight or power/bulk ratio.

The following statements in the paper are worth quoting:—

Page 9: "It also seems to be generally accepted—although the author does not agree with this view—that the two-stroke has and will retain an overwhelming superiority in power/weight and power/bulk ratio."

"The two-stroke as it exists to-day is a very bulky engine for its displacement."

Page 10: ". . . they are sufficiently accurate to establish the main point at issue, which is that the two-stroke compression-ignition engine is not, at the moment, leading the field commercially on vehicle engines with regard to light-weight and compact power units."

Supporting these observations are diagrams 5, 6 and 7 on pages 11 and 12, which all show quite clearly that the Cummins, which is a four-stroke, direct-injection-blown diesel engine, leads the field in power/weight, power/bulk and power/length ratios.

I should be glad if you could publish this letter in order that the correct facts may be established.

W. A. ROBOTHAM

Belper, September 4th

Literature

Heat Transfer. By MAX JAKOB. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 96s.

THIS, in many ways, is the book for which research workers, and all those interested in the fundamental aspects of the science of heat transfer, have long been waiting. The author, who was formerly Director of the Laboratories of Applied Thermodynamics and Heat Transfer of the Reich's Institute of Applied Physics, has for many years been one of the most prominent figures associated with heat transfer. He has himself published a very large number of important papers, covering a very extensive field, among which his researches on heat transfer in the boiling of liquids and the condensation of vapours are perhaps especially well known. The purpose of his book is "to show the development of the ideas which led to the present state of our knowledge in the branch of science and engineering called heat transfer" and, as stated on the cover, "empirical material is used mainly for illustration, for verification, or for showing the deficiencies of theoretical analysis." In pursuance of this plan, the derivations of the more important theoretical solutions have been given "in such detail that study of the original papers will be necessary only in exceptional cases." This refers particularly, although by no means exclusively, to the German literature, and will be of the utmost service to all concerned, saving them a great deal of time and frustration in efforts to go back to original sources, which are often difficult of access. But, important as these considerations may be, the book achieves far more, since, although emphasis is laid on fundamental analysis, most of the accepted empirical expressions based upon experimental correlations are given, compared with the appropriate theoretical expressions, and the reasons for any disagreement discussed.

The present book forms Volume I of a complete treatise, and is divided into five parts, comprising: (A) Basic equations of heat transfer; (B) Properties of matter significant for heat transfer; (C) Heat conduction in simple bodies; (D) Heat convection without change of phase; and (E) Heat convection including change of phase. It is to be followed shortly by a second volume covering (F) Heat radiation in spaces of simple configuration, and (G) Selected fields of application such as thermometry and heat exchangers.

Considering the wide scope of the work, it is not surprising to find that Volume I extends to over 700 pages. An introductory chapter describes the three different kinds of heat transfer, namely conduction, convection and radiation, and is followed under (A) by three chapters discussing the basic equations of heat conduction, heat convection, and heat radiation respectively. How complete is the treatment may be illustrated by the fact that the derivation of the Stefan-Boltzmann law of radiation, and the main features of the derivation Wien's displacement law, are included.

Part (B) comprises chapters on viscosity, thermal conductivity, and emissivity, the introductory chapter giving a short but useful account of the viscosity of liquids and gases, including "theoretical relations about the viscosity of gases," under which is to be found a discussion of the theoretical independence of the viscosity of gases of pressure, and the variation with temperature as derived from the work of Sutherland and Maxwell. But only a few numerical values of viscosity are given, and these, for gases, apply only to atmospheric or lower pressures, except in the case of steam, for which values are included for pressures up to 1500 lb per square inch, as derived from the experiments of Hawkins, Solberg and Potter (1940). Practically nothing is said about the probable accuracy of these values, or of the discrepancies between the results obtained by different observers. The following chapter deals with the theory of thermal conductivity, and shows how expressions have been derived which allow of the thermal conductivity of a gas being calculated from its viscosity and specific heat. The most reliable procedure for this purpose is discussed at some length, and corrections given to allow for differences in the nature of the molecule under consideration. Theoretical considerations of the thermal conductivity of liquids and of porous solids are included, and the relation between the thermal and electrical conductivities of gases discussed. Some tables of thermal conductivites are given, but the units in this part of the book are not systematic, viscosity appearing in c.g.s. units, and thermal conductivity in British units at temperatures on the Centigrade scale, which seems a little illogical when similarity methods of correlation are used so generally. The remaining chapter of this part of the book is concerned with emissivity, and a few selected values are given. Only about a page is spent on the absorptivity of gases, presumably since gas radiation is to be dealt with more fully in Volume II.

The next part of the book (C), comprising conduction, runs to nearly 400 pages, successive chapters covering heat conduction in steady state without heat gains or losses, conductivity measurements, heat conduction in steady state with and without internal heat generation and heat dissipation to the environment, in non-periodic temperature changes with and without heat losses or gains, and at variable temperature, including internal heat generation and heat dissipation to the environment. Some applications of the unsteady state equations follow with, finally, an account of special mathematical methods, and numerical, graphical and analogical methods, used in heat conduction problems. Possibly the length of this part of the book is a trifle out of balance, especially since standard works on heat conduction deal with some of the matter included.

The final parts of the book, (D) and (E), are concerned with heat convection with and without change of phase, and include similarity between heat convection and mass exchange, and heat transfer in evaporation and condensation. They run to less than 300 pages, and are thus considerably shorter than the section dealing with conduction. A very valuable chapter is that giving analytical solutions of the convection equations, since these have not previously been available in anything like so compact, precise and convenient a form. The comprehensive account of similarity relations for heat convection is equally valuable and authoritative.

It might reasonably be assumed that the presentation of data in specially simplified forms for the use of practical engineers and designers would be outside the scope of such a treatise as this, and in fact, little attempt is made to give such data. But the excellent accounts of the relation between experiment and theory for both natural and forced convection, boiling, condensation and evaporation are one of its most important features, and, together with the wealth of information in the earlier sections of the book, should make it an essential addition to the libraries of all serious students of heat transfer.

Gearcutting Practice. By FRED H. COLVIN and FRANK A. STANLEY. London: McGraw-Hill Publishing Company, Ltd., Aldwych House, W.C.2. Price 40s. 6d.

THIS book, which now appears as a revised third edition, is built up largely from the sort of information published in the catalogues and instruction books of American manufacturers of gears, gear testing equipment and gearcutting machinery. It contains sections on the hobbing and shaping of spur, helical and internal gears, and a section on the finishing of gear teeth by burnishing, shaving, lapping and tooth grinding. There are chapters on bevel gearcutting, worm gearing, gear inspection, and heat-treatment. Selections from A.G.M.A. standards and the American Standard Association relating to gears and involute splines are quoted throughout the book.

The book is written and illustrated almost exclusively around American practice, but one feels that it would have given a better picture of the present state of gear manufacturing practice had it been a little more international in character. Although the hobbing and shaping methods of cutting spur and helical gears are very adequately dealt with, there is hardly any mention of the rack generating process which has been highly developed in this country and in Switzerland. Considerable space is rightly given to the finishing of gear teeth by shaving, a process which was originally introduced and developed in the States, but gear tooth grinding is relegated to a few pages only, and the Maag gear grinder, which deserves a place amongst the best in the world, is not illustrated.

Although American practice in regard to worm gearing lies some distance behind British practice, the authors have not made use of the best available material in the States, and the chapter on worm gearing is disappointingly inadequate. No reference is made to such first-rate American machines as the Pratt and Whitney thread grinders and thread millers, the Jones and Lamson worm thread grinder, or the Gould and Eberhardt worm wheel hobbers. It is understandable that practically nothing is said about the involute helicoid worm, because the American gear manufacturers do not as yet seem to be aware of its advantages in manufacture and performance, and consequently the American machine tool builders have not been called upon to produce thread grinders specially adapted to its manufacture. Some space is given to a description of the latest offspring of the Hindley worm, and a seven-page description of how to cut a worm wheel on a milling machine is given!

In the section on heat-treatment one would like to have seen some detailed description of the gas carburising process, so widely used in the States and just beginning to find its way into this country.

The American machines and equipment for inspecting gear elements are expensive and luxurious, but undoubtedly good, and the section on this subject shows the attention given in the States to the checking of small and medium-size gears. There is a notable absence of any good worm gearing testing equipment, such as is made in this country. The section on bevel gearing is naturally devoted mainly to the practice of the Gleason Company, whose products are of such excellence as to meet with little competition from any other source.

Vitalising the Foreman's Role in Management. By GLEN GARDINER and ROBERT L. GARDINER. London: McGraw-Hill Publishing Co., Ltd., Aldwych House, W.C.2. Price 30s. net.

THE correct place of the foreman in an industrial organisation is one that has never been clearly defined, for although most agree that he should be recognised as part of the management, too often he is treated by the upper officials as if he were part of the manual team, while the men on the shop floor are prone to view him with suspicion as being identified with management. The authors, father and son, definitely and, we believe, correctly start with the assumption that a foreman is essentially an integral and important part of the management, and their intention in writing was to explore the means of ensuring that foremen more fully participate in management, realising their position and thereby contributing the maximum value to the organisation.

The first chapter clearly sets out the role of the foreman, while succeeding chapters deal with such questions as: the factors that alienate foremen; the best means of selecting the right men for foremanship; the status of the foreman, and how it is affected by the conditions under which he is expected to work; whether a so-called foreman is in reality a foreman vested with the necessary powers, and in this connection the important matter of establishing sound relationships between the line organisation and staff departments is raised, a frequent source of trouble often leading, quite unnecessarily, to a feeling of frustration; what is on the foreman's mind and what can be done to help him understand his position; the necessity for giving full facts and the most satisfactory manner of so doing; the desirability of pooling management information; how to ensure that foremen may participate in the making of policy; the way in which a foreman can assist in securing a greater degree of safety in his department; his responsibilities regarding the settlement of grievances as they may arise, and the necessity for his powers of action being clearly defined. Each of the foregoing subjects is well thrashed out and the suggestions made should be valuable alike to foremen and higher executives. The concluding chapter (XII) gives eleven specific programmes adopted by some influential American companies, each designed to promote foremen's participation in management and each worthy of careful consideration. British engineers might think twice before adopting the expedient of a New Jersey company, which transports its 150 foremen to a "Looking Ahead—Management Conference," which is held at a seaside hotel in the autumn. The party arrives on a Friday afternoon and proceedings open with a banquet, followed by addresses by the chairman of the board on "New Horizons," &c. Next morning is devoted to a series of short papers by leading officials. After lunch comes an afternoon of recreation, followed by a dinner banquet. Sunday is left free for occupation to suit individual tastes. It is claimed that the whole proceedings produce a real *esprit-de-corps* and enable those designated by the authors as "top executives" to establish contacts with foremen which would otherwise be difficult.

There is so much in this work that is of a constructive, informative and helpful nature that it is hard to select any particular subject for special reference, but all managing directors and works managers, indeed all executives, will find much to interest them and raise lines of thought that are bound to be productive of good.

The book is written with American industry in mind, but the principles enunciated are common to all industry, and the authors have put their fingers on several points where British engineers have failed, thus in the attempt to train men for foremanship they have evoked resentment by supervisors feeling that they were being "sent back to school," whereas it is essential that the class room atmosphere should be removed. Many of the proposals might well be put to the test in this country. Foremen are often reticent about stating what is in their minds, whereas if they are confronted with a pointed questionnaire coupled with the assurance that their names will not be divulged and that the answers will be treated confidentially, they are found to respond readily. A typical questionnaire on thirty-three distinct items is cited as an example. Lack of information as to company policy is often a source of real annoyance to the intelligent foreman, and a system of regular information letters headed "For Your Information," and issued as occasion demands by the works manager proves very helpful. Not only should information be passed down the line, but there should be a "three-way transfer," ensuring in addition both upward and lateral flow. Too often foremen in one department are ignorant as to the activities in another department.

We have only touched lightly on a number of interesting points, but all who occupy supervisory posts would profit by considering the contents of this book carefully, for if the principles advocated were more wholeheartedly applied the foreman would cease to be the Cinderella of industry, and would assume his responsible post with assurance and the whole organisation would benefit.

Stationary Compression Ignition Engines—Principles and Application. By C. H. BRADBURY, M.I.C.E., M.I.Mech.E. London: E. and F. N. Spon, Ltd., 15, Bedford Street, Strand, W.C.2 Price 24s.

THOSE who know Mr. Bradbury will not be surprised that his book has all the marks of having been based primarily on his own practical experience and research. He tells us what he has learned rather than what he has read, and—as Sir Harry Ricardo puts it in his "Foreword"—this has been done "with admirable clarity and a refreshing simplicity." To the making of books about oil engines there is no end and many of them are defective in that they lack the ring of authentic experience. Mr. Bradbury might have written his book in an engine works, where the matters with which he deals were constantly passing on to his desk for immediate study. That is why he has succeeded so well in his brief exposition of the problem of injection, which lies at the very heart of the compression ignition engine. While wasting no words on purely historical details, Mr. Bradbury takes a look back on Akroyd Stuart struggling—in 1890—with the jerk pump. It has been said that experience can be compared with the stern light on a ship: it only illumines the track behind. Even if we could believe that this is the sole function of experience it is indeed a very valuable function, and as we scan the evolutionary track of the compression ignition engine we are able to appreciate the extent to which its progress has depended upon the development of the injection details. As a small rearrangement in further editions, we suggest that Plate I (spill-valve pump) should be printed not opposite page 128, but opposite page 52, and thus in the midst of the chapter on injection. The considerable time which we spent in finding Plate I would have been saved had there been, in the text on page 52, a reference to the page on which the plate is printed. We also suggest that a section to larger scale and in the form of a sectional drawing would be better than the tiny block provided.

Mr. Bradbury does not enlarge on the extent to which fuel pump delivery pressures have risen, these being now quoted in tons per square inch, at which intensities they may be the occasion, we do not doubt, of considerable perplexity to makers and users of injection equipment. If the high pressures are required in using low viscosity fuel, we may suppose that the use of high viscosity fuel will present still further problems not only to the maker of the injection equipment, but to the engine designer, who has to provide the driving means. The chapters on Combustion, Charging, Balancing, Torsional Vibration, Fluid Couplings, Foundations and Parallel Operation contain much information in a form which, while concentrated, retains that clarity so often missing in books of this character. Mr. Bradbury is cautious in references to the advance in b.m.e.p. obtainable with turbo-blower charging. "There is no doubt," he remarks on page 82, "that advances on 120 b.m.e.p. are now possible commercially." Our own opinion is that these advances must be made with much circumspection and the ground tested step by step in actual practice. Experience rather than enthusiasm is the safe guide for engineers, particularly internal combustion engineers. On indicators, Mr. Bradbury does not mention the recent introduction of a very simple peak pressure indicator with which the checking of compression and firing pressures can rapidly be carried out. We doubt whether, with modern instrumentation, it is necessary, on compression ignition engines, to go to the expense and complication of providing normal indicator gear.

Readers of this book will turn, as did the present reviewer, to the chapter on Maintenance, and though they may not agree that "the question of a suitable engine for a given duty can safely be left in the hands of the manufacturer," they will appreciate the useful advice given by Mr. Bradbury in what is, from certain points of view, his most valuable chapter. These are the notes of an experienced man and there can be no engine user who does not get to learn that the operational success of an installation is largely determined by the adequacy of the accessory equipment and the faithfulness of the maintenance. Mr. Bradbury omits mention of the increasing use of water/water heat exchangers for closed-circuit cooling; of magnetic strainers on lubricating oil and fuel oil lines and of devices and procedures for lessening the danger due to crankcase explosions. We suggest that in later editions he should deal with these matters and also with the clamant need for a higher degree of skill in watch-keeping engineers and maintenance men. We offer the further suggestion that his excellent section on "Definitions" should include a conversion table for certain English and metric units. The book is certainly worthy of being enlarged in the directions indicated, though in saying this we do not omit to commend the volume, in its present form, to all those whose business it is to deal with the manufacture and use of stationary compression ignition engines.

BOOKS RECEIVED

Principles and Use of Surveying Instruments. By J. Clendinning. London: Blackie and Son, Ltd., 66, Chandos Place, W.C.2. Price 15s.

New Times, New Methods and New Men. By V. M. Clarke. London: George Allen and Unwin, Ltd., Ruskin House, 40, Museum Street, W.C.1. Price 10s. 6d.

The Fifteenth Commercial Motor Show

No. I

THIS autumn Earls Court, London, again becomes the focal point of interest for all concerned in the varied products of the motor industry.

Two great events in close sequence, the Commercial Motor Exhibition and the Motor Show, afford an unequalled opportunity for the general public as well as traders and operators from home and overseas to compare, under ideal conditions of presentation, the respective merits of the world's leading motor vehicles and allied products, with the accent on those manufactured in Great Britain and America.

The first of these events, the Commercial Motor Exhibition, was opened on Friday, September 22nd, by Mr. A. J. Barnes, M.P., Minister of Transport. The Show, staged biennially, was first held in 1907; it was necessarily postponed during the war years and revived in 1948, when it created a new record in both range and quantity of exhibits and in attendance figures. Since the war the industry has made remarkable progress in spite of difficulties in the supply of essential materials. Output has risen from 146,000 vehicles in 1946 to the present annual rate of 268,000. This compares with a total production of just under 104,000 in 1938.

The motor industry as a whole plays a vital part in the nation's export drive, accounting for more than 10 per cent of the total exports. The commercial vehicle manufacturers' contribution is equally striking; more than ten times as many vehicles are exported now than in 1938, and in the first half of 1950 alone, 73,000 vehicles, worth over £30 million, were exported, amounting to more than half the total output.

Although it is still considered necessary to restrict the supply of vehicles to the home market, supplies have been at a higher rate than before the war. In 1938 home buyers took 90,000 vehicles, whereas in each of the past four years the figure has been over 100,000. In June of this year there were 872,000 goods vehicles on the roads of this country serving our home industries, as against 513,000 before the war. There were 73,000 public service vehicles in March, compared with 52,000 before the war, a fact which represents the very remarkable change in the travelling habits of the public.

The increased dimensions for single-deck buses and coaches recently approved for operation in this country (up to 30ft in length and 8ft in width), and the consequent construction of larger vehicle exhibits, has presented the organisers with a particularly difficult problem in the general allocation of space. Even so, the traditional planned lay-out has been well maintained and an overflow of bodywork exhibits, mounted on various chassis, had to be displayed in the demonstration park adjoining the building.

The number of firms represented, catering for all aspects of manufacture of commercial vehicles and allied products, amounts to nearly 450, amongst them forty-one builders of commercial vehicles and sixty-nine body-builders and trailer manufacturers.

Among the 400 vehicles of all types on show there is one of the largest tractors in the world, the Thornycroft "Mighty Antar," 85-ton tractor, built for operation in Iraq, in conjunction with a 45-ton semi-trailer, which was described in our issues of April 28th—May 19th, 1950.

Another remarkable exhibit is the Latil six-wheeled tractor, with drive on all wheels, capable of climbing 1 in 2 gradients, ploughing through 2ft of mud, traversing powdery sand, crossing swamps and marshland and—with special waterproofing equipment—of wading through water to a depth of 6ft.

A seventy-seater, all-metal double-deck trolleybus of the British United Traction Company represents one of the largest vehicles used on British roads to-day. Nearly thirty new chassis are on show for the first time, many of them passenger vehicles with unorthodox engine mounting.

Some General Trends

Before the opening of the Exhibition there was a certain amount of speculation as to whether or not we were likely to witness a radical departure from traditional British design as applied to the conventional forward control. In fact, the majority of the vehicles on show, buses as well as lorries, still position the driver's seat on one side of the engine. Only in cases where the driver's comfort would be adversely affected by climatic conditions, for instance, by tropical heat or in countries where there are no length restrictions, is the bonnet-type an alternative to the forward control. On the contrary, it seems that on the Continent, even in countries which before the war were rather reluctant to adopt this system, it is now definitely gaining ground for lorries in spite of the adverse attitude of many drivers who prefer the more comfortable and less noisy cab behind the bonnet.

It has to be remembered, however, that the forward control, with the driver's seat on one side of the engine, makes it necessary to position the auxiliaries, for accessibility reasons, on the opposite side. This develops the one-sided engine, which poses some difficult design problems in cases where the vehicle is to be exported to a country with the right-hand rule of the road. It is interesting to see how our designers have solved this problem, as a rule by having the crankshaft entirely symmetrical in relation to the vertical line of the engine, thus making it possible to reverse the engine completely. As the vertical engine satisfies all reasonable requirements for accessibility, easy maintenance and servicing, there seems to be very little reason to give up this basically sound design, the more so as a different mounting of the power unit would not result in any considerable gain as far as platform space is concerned.

In these circumstances we do not suggest that the forward control is getting out of date, although it must be admitted that there are very definite indications that our conventional ideas about the most suitable position must be revised, in any case, as far as passenger vehicles are concerned. This tendency is neither novel nor is it confined to this country, but the reasons why our manufacturers in the past have been reluctant to make drastic changes in this respect may be based on the fact that, before the war, the major demand for our buses has generally been from users in this country and overseas customers have accepted vehicles conforming with our own standards.

Generally speaking, the vehicles exported were models supplied to the home market. The post-war years and the need for greater export, however, have brought about a change. British manufacturers, faced with increased competition, originally from America, but nowadays from the Continent as well, were compelled to provide a new range of vehicles to meet overseas conditions more adequately. Over a long period representations have been made by commercial vehicle interests to secure changes in legal requirements so as to allow the basic dimensions of passenger and goods chassis to be comparable with those generally recognised as overseas standards. One by one and, obviously with reluctance, the Ministry of Transport has amended some out-of-date restrictions, with the result that the 8ft overall width of passenger vehicles is now gradually becoming the standard. But, with the still existing restriction of an overall length of 30ft, for two-wheeled passenger vehicles, our manufacturers are still compelled to produce two models, one for home use and one for export; neither is as economical as it might be, and both are more difficult to sell in competition with manufacturers in other countries not so handicapped. It should be earnestly considered whether home regulations, particularly those relating to the speed limits for the different types of commercial vehicles, should not be relaxed, as it is obvious that vehicles built under these restrictions cannot be useful in the majority of overseas markets. Failure to bring home regulations in line with overseas ones imposes onerous trade restrictions and must necessarily affect the productivity in a manufacturing industry that has made and continues to make a substantial contribution to this country's exports.

The Underfloor Engine

Our principal competitors for single-deck buses overseas were the Americans, who were exporting chassisless buses with either underfloor or rear engines in large numbers. In their search for greater utilisation of the plan area within the limited legal dimensions, our manufacturers had, in the past, experimented with power units mounted either on one longitudinal frame member, midway between the front and rear wheels ("Q"-type of A.E.C.) or below the chassis. It will be remembered that in 1937 Tilling-Stevens, Ltd., created something of a sensation with a flat-engined, six-wheeled chassis, in which the power unit was mounted amidships below frame level. A similar design has been propagated for a considerable number of years by Sentinel, who are using this system for passenger as well as for goods vehicles.

Since the war manufacturers in other countries, in U.S.A. as well as on the Continent, have been quick to appreciate the advantages of the underfloor engine and a number of thoroughly practical and successful designs have evolved. In addition, the U.S.A. has introduced buses fitted with rear engines in which the power unit was either mounted parallel to the centre line of the chassis or in conjunction with an angular transmission line transverse to it. The latter system has been adopted in this country by Foden; the engine is carried in the frame, parallel to and behind, the rear axle and the output shaft is connected by bevel gear to the gearbox, which is secured at right angles to the power unit. A short propeller shaft connects the gearbox with the worm drive of the rear axle.

The advantages of the rear engine compared to the underfloor engine are the

greater accessibility of the power unit and the fact that the chassis can be kept low without impairing the ground clearance. On the other hand the system is confined to passenger vehicles only and presents some difficulties in the operation of clutch, gear-change and engine control, owing to the long distance between these units and the driver's cab. Furthermore, it does not fully achieve the main objective, namely, to provide the greatest possible passenger space within given box dimensions. Better in this respect is the underfloor engine and practically all our big manufacturers, such as A.E.C., Atkinson, Crossley, Dennis, Guy, Leyland, Maudslay and Sentinel, have now adopted this arrangement as the most suitable one for our home requirements, as well as for our main export markets. By placing the engine beneath the floor an

ROYAL TIGER COACH—LEYLAND

uninterrupted single-deck can be obtained and the passengers have the complete plan area at their disposal, except for a small compartment for the driver. Other advantages may be secured by this system, notably better weight distribution, improved methods of entrance and exit and insulation of noise and fumes. Buses built for home use according to these principles, with a width of 8ft, can seat up to forty passengers or even more, in comfort, whereas the orthodox single-deck bus with forward control did not provide accommodation for more than thirty-two. If the legal length limit could be raised to 35ft, it would be possible to seat at least forty-eight passengers in comfort, a number approaching that accommodated by the double-deck arrangement, without any of its attendant disadvantages (limitations of speed, softness of suspension and inconvenience to passengers).

Contrary to first thoughts, the accessibility of the engine is not impaired to any great extent; by skilful arrangement of the accessories, the maintenance of such vital units as injection pump, injectors, valve gear, filters, &c., can be carried out from outside the bus and even the complete removal of the power unit should be possible in well under half an hour.

The adoption of the underfloor engine by our leading manufacturers will be welcomed in the end, even by bus operators who hitherto have given designers no encouragement to depart from the traditional construction. It will be appreciated as an indication of the vitality of British vehicle design and of the determination of the industry to tackle an important task with unorthodox means. There will also be satisfaction in the comparatively small circle of experts, who, for more than a decade, have been protagonists of the chassisless or integral bus, that this construction is about to emerge from the prototype stage and that, at last, the production of such vehicles has begun in earnest. Buses of integral construction are the rule rather than the exception in U.S.A., and since the war have been adopted by a number of Continental manufacturers. The method itself is not new in this country and, in fact, Metropolitan Cammell Weymann built chassisless trolleybuses for London Transport in 1936. Another chassisless bus in aluminium construction, built by J. C. Beadle, Ltd., and fitted with a Sentinel underfloor diesel engine, was exhibited on the occasion of the 1948 Commercial Vehicle Show.

It is generally recognised, however, that the integral construction is only sufficiently attractive in combination with the rear engine or, better still, with the underfloor engine. This enables us to build a very strong structure of comparatively light weight and to design the vehicle as a complete unit, strong enough to resist fatigue, corrosion and accidental damage. As the longitudinal members of the body vertically extend in depth from the floor line to the underside of the windows, they form a very stiff girder, strong enough to take up very considerable bending moments, whereas the transverse frame members, in conjunction with the pillars and the roof, have to take up the torsional stresses. The complete power unit, as outlined before, is then mounted below the floor, halfway between the axles, the latter being attached to suitable anchorages. An interesting example in this respect (illustrated herewith) is the Leyland "Olympic" single-decker on show, built for South America, which, with an overall length of 26ft, can accommodate forty passengers. The metal construction employs tubular steel pillars and steel truss panels.

With the exception of two firms, Sentinel and Commer, no other firms have, so far, adopted the underfloor engine for goods vehicles, although this engine mounting presents no insurmountable difficulties. The main objection towards its general applications seems to come from small operators, who claim that the repair and servicing of the underfloor engine require personnel which has to be specially trained for this particular job. They further maintain that the engine, or at least some of the more delicate auxiliaries, might be affected if abrasive or corrosive material has to be carried. Also the possible saving of platform space is considered to be rather insignificant and, in any case, not big enough to justify the higher cost of an underfloor-engine chassis.

From the manufacturer's point of view, however, it would be a great advantage if he could build chassis equally suitable for goods and for passengers, although this possibility is unlikely to materialise in its full implications. The question of the steering side would be immaterial in such a vehicle and, a rather important item, the driver and two more men could be comfortably accommodated in a roomy cab, unaffected by noise, heat and fumes.

(To be continued)

A Clip-On Ammeter for Heavy Duty Conductors

A RECENT addition to the range of clip-on ammeters made by Ferranti, Ltd., Hollinwood, Lancs, is illustrated herewith. The instrument has been specially designed for use on porcelain-clad fuses (which are too large for the normal type of clip-on ammeter) and will accommodate fuses and heavy duty conductors up to 4in in diameter. Seven ranges of measurement are provided up to a maximum of 1000A a.c.

The new ammeter (type 17L) consists of a current transformer with a large, fully insulated centre-opening core and a 2½in rectifier type

HEAVY DUTY CLIP-ON AMMETER

instrument housed in a neat black Bakelite case. The magnetic joints of the core are self-aligning under the influence of a powerful spring, thereby ensuring consistent accuracy of readings. As suggested by our illustration, the range selector switch is conveniently situated for thumb operation and the whole instrument is well-balanced and easy to manipulate with one hand. Normally the instrument is suitable for use on circuits of 50 to 70 cycles but if specified at the time of ordering calibration can be carried out at a particular frequency. The ammeter can be used with safety on bare conductors up to 600V a.c. The handle is slotted to take a carrying strap and a leather case with shoulder strap can be supplied as an extra.

FERRO-SILICO-CHROMIUM.—The Treasury has made the Import Duties (Exemptions) (No. 9) Order, 1950, which exempts from import duty ferro-silico-chromium containing not less than 20 per cent of silicon and not less than 10 per cent of chromium. The Order came into operation on September 21st.

Iron, Steel, Engineering and Metallurgical Industries in South Africa

(By our South African Correspondent)

SOUTH AFRICA'S Board of Trade and Industries, while recording that, generally speaking, prevailing duties on precision, light and heavy machined metal products are low, announces that it has no intention at this stage of proposing that the tariff should be altered. This decision is contained in a report on these products issued by the Board of Trade as part of its investigation into the iron, steel, engineering and metallurgical industries of South Africa.

Dealing with the technical efficiency of the precision section of the engineering industry, the Board says that the degree of accuracy and quality of workmanship found in the relatively small range of locally made precision engineering products is, on the whole, of a high standard. This applies in particular to the rock-drilling equipment manufactured in the Union and the reputation enjoyed by rock-drill producers is an indication of the capabilities of the local precision engineering industry. This industry is fully capable of meeting overseas competition and has, indeed, been instrumental in bringing down the prices of these products. The report shows that in 1946 (latest statistics available) production of rock-drills and rock-drill spares in the Union was valued at £672,273, as against £371,562 for the value of imported rock-drills. In 1939 local production was only worth £359,296.

The statistical information on other precision machine-shop products is incomplete and unreliable. It can, however, be accepted as a fact that local output accounts for only a small part of national requirements in this respect. The limited manufacture of precision products for general engineering purposes has, in the past, generally been on a jobbing scale and expensive in comparison with the imported commodities. This position is now changing, however, there being a marked tendency on the part of precision engineers to extend their range of manufacture and, in some cases, new workshops have been established for the purpose of manufacturing precision equipment for more general engineering purposes, such as inspection gauges, production jigs, plastic moulding dies, thread taps and automobile pistons.

The Board states that specialised machines, such as boot and shoe-making machinery, internal combustion engines, printing machinery, sewing machines, sugar machinery and textile machinery, have not as yet been manufactured economically or on a competitive basis in South Africa. It notes, however, that the output of the engineering industry is made up on "an exceedingly wide range of items in ferrous and non-ferrous materials," and, owing to the very wide variety of services and products involved, it asks that any opinion expressed in general terms as to quality "be accepted with reservations." There appears to be a strong tendency on the part of light engineering concerns to attempt too wide a range of work, with the result that quality sometimes suffers, because of the lack of suitable equipment and plant. On the whole, however, the standard of workmanship is good. Production costs, on the other hand, are often high, the main reason probably being the fact that the quantities demanded are small. As a consequence, the setting-up time is excessive in relation to the actual cutting time and the methods employed and the jigs, tools and fixtures used have to be of a simple nature and not designed for quantity production. The Board thinks another factor which needs to be stressed is the absence, in general, of incentive payments based on accurate time standards.

Turning to factory and plant lay-out, the report says that while more recently established precision engineering concerns are operating in spacious workshops designed for their class of work, many older concerns work under indifferent lighting conditions with up-to-date manufacturing methods superimposed on an out-of-date plant lay-out. With some exceptions the light engineering workshops engaged in work of a general nature are attached to jobbing foundries and large numbers of them are therefore nearly always inadequately lighted and often unduly congested. A limited number of light machine shops are housed in suitable premises and are very well organised and there is a tendency for the older concerns to redesign their establishments on more up-to-date lines. A similar state of affairs applies to heavy machine shops, most of which are not usually equipped for quantity production, although several of them are becoming organised for the manufacture of new machinery of comparatively heavy calibre, and the potentialities for development in the field of heavy engineering are illustrated by the fact that some of those concerns in combination have successfully made and marketed batches of tube-mills and winding engines.

On the score of equipment, the Board of Trade finds that local precision engineering workshops are generally well equipped for the class of work undertaken by them and that there has recently been a "marked change" in the equipment of light machine shops, which, only a few years ago, was generally out-of-date.

The modern equipment imported during the last war and the latest machine-tools acquired by these concerns since the cessation of hostilities have, in a large number of machine-shops, replaced most of the antiquated equipment," the report says. "The installation of this efficient machinery must tend to reduce production costs and is, incidentally, placing the firms concerned in a position to make a fuller and more efficient use of operative labour."

It is pointed out that a phase of workshop organisation which is sadly neglected is the question of internal handling facilities. In a number of plants finally-machined and partly-finished products are still handled and transported by inefficient methods.

The equipment of heavy machine shops is generally old and the Board thinks that, bearing in mind that the scope for that class of manufacture is still comparatively limited, it is doubtful whether heavy engineering firms other than the corporation associated with the Iron and Steel Corporation (namely, Vanderbijl Engineering Corporation) can reasonably be expected to invest capital in the same class of equipment.

In the section of the report dealing with control of production and quality, the Board feels that while precision engineering firms have attained marked success in the production of rock-drill components, no serious attempt has been made as yet to apply the same methods to more general engineering purposes. That is probably due to the limitations of the market for such lines. In the case of light engineering concerns, the position is somewhat different as little evidence exists to show that production planning and costing has been given any particular attention in the past. In many cases it is doubtful whether many of these concerns could give anything approaching an accurate estimate of the cost of any job before it had been completed, and this fact has led to a considerable amount of inefficient manufacture and uneconomical competition. The position which permitted that unhealthy state of affairs is changing rapidly, however, and the more efficient manufacturers are paying increasing attention to control measures. In the past the control of quality generally depended on the craftsmanship of the artisans concerned and the efficiency of their production supervisors. In small workshops engaged in jobbing work, that method of controlling workmanship and general finish was, in most cases, quite satisfactory. But for quantity production the old supervisory system of control is totally inadequate and in most cases only results in considerable loss on account of unsatisfactory work. Some of the companies engaged in that class of manufacture have already appreciated that fact, with the result that they have established inspectorates in their workshops. Most manufacturers in the light engineering group have not yet taken those necessary steps and will continue to encounter difficulties until they establish more positive quality control measures.

As heavy machined products are only ordered in small numbers, the report records that quantity production methods cannot be applied to this class of production, but "very efficient production control is essential for the economical manufacture of such a wide variety of products." Firms falling in the heavy engineering category have not always been suitably organised with the result that costs have not been properly controlled, but the importance of efficient production planning and costing is being more fully appreciated and efforts are being made to establish more suitable production control methods.

On raw materials, the Board says that all the simpler ferrous and non-ferrous alloys and plain carbon steels are produced in South Africa and these materials are available from local sources in practically all the forms necessary for making nearly the full range of general machine-shop production. "Quantities of these materials have to be imported from time to time, but this is only due to the fact that, at present, the demand exceeds the supply and the position will improve when the metallurgical production in the Union is suitably increased." Certain special alloys are imported in comparatively small quantities for certain machinery parts and precision equipment. A limited number of specialities, such as ball races, gauges, valves and patented components, have to be purchased from overseas manufacturers, but the expenditure involved forms only a negligible part of the value of the Union's imports.

The report adds, in conclusion, that up to a few years ago heavy forgings could not have been produced in South Africa, but that disadvantage had been eliminated. As a rule, very heavy castings still have to be imported but steps are being taken to establish a foundry for that class of work.

Additional Steel Capacity for the U.S.A.

Two subsidiary companies of the United States Steel Corporation have announced plans to increase sheet and tin plate capacity by a total of almost 300,000 tons per annum in the West. The Columbia Steel Company will install additional cold-reduced sheet and tin plate facilities, with an annual capacity of 200,000 tons, at its mill at Pittsburgh, California. The new equipment will include a continuous pickling line, a four-stand 54in cold strip mill, an electrolytic tinning line, four coil annealing furnaces, a side trimming and recoiling line and a continuous sheet galvanising line. The latter is a new development and will be the first of its kind to be installed in the West.

The Geneva Steel Company is adding facilities at its mill at Geneva, Utah, for the production of almost 100,000 tons of additional hot-rolled sheets yearly. A new building will be erected at Geneva to contain the new sheet facilities. When both these expansion programmes have been completed in the middle of next year the two companies will have a combined annual capacity for the production of approximately 580,000 tons of sheet and tin plate products.

Gas Turbines for Industrial Purposes*

By Dr. A. T. BOWDEN

WHEN the development of the industrial gas turbine, which had been taking place slowly before the war, was quickened as the result of the spectacular success of the jet fighter, it found the steam turbine and diesel engine firmly entrenched for large and small or medium power outputs, respectively. If it were to invade the fields held by these prime movers it had to face the high efficiency of the diesel engine on the one hand and the high specific output of the steam turbine on the other. On both counts it was severely handicapped by virtue of the cycle on which it operated.

The fact that compression, combustion and expansion take place in the same locality in the internal combustion engine enables the peak temperature of the working medium to be raised much higher than the maximum permissible temperature of the material. At the same time constant volume combustion is possible, giving a better ratio of positive to negative work. With the gas turbine, however, compression, combustion and expansion are separated in space and constant in time and apart from special conditions the maximum permissible temperature of the material is at the same time the limiting temperature for the cycle.

To offset these disadvantages the gas turbine can handle large volumes more readily than a reciprocating engine, the operating pressures are low, and so it can produce more power with a given space and weight than its industrial diesel counterpart. It will probably burn an inferior grade of oil fuel and lubricating oil costs are very light.

All conventional means available to the gas turbine for improving its efficiency to the level of the diesel engine involve space and weight. (This is true not only because the conventional types of heat exchanger are bound to become large and heavy with increasing thermal efficiency, but also because the best efficiencies are only achieved with small pressure ratios and comparatively small specific outputs.)

The main developments demanded by the above analysis are light, compact and efficient heat exchangers and further developments in metallurgy so as to raise the maximum permissible gas temperature. To these must be added all such arts as enable the gas turbine designer to widen the gap between gas and material temperatures as, for example, by cooling. What of the position of the gas turbine in the wide field hitherto held undisputed by the steam turbine ? It is always dangerous to attempt to predict the developments of a given type of prime mover. Well-informed critics were not wanting only some forty years ago who considered that the development of the steam turbine had then reached its limit. Few could have believed then that pressures of 100 atmospheres and temperatures of over 1000 deg. Fah. were likely to be standard for large units in fifty years time. In comparison with the steam turbine, the gas turbine suffers as already noted from a relatively low specific output, but the particular feature which gives it a chance to compete is the fundamental soundness of its operating cycle, which makes it superior to the steam cycle and its high degree of adaptability, which enables its efficiency to be continually improved, provided it can be made bulkier, heavier and more expensive. It is upon this—the fundamental soundness of the cycle—that development will depend, and it may therefore be of interest at this stage if a short comparison is made of the steam and gas turbine cycles and of the directions in which they have already moved and are likely to move in the drive for higher efficiencies.

Right at the beginning it will be noted that the gas turbine has still further to reduce its specific output, which in comparison with the steam turbine is already its weak point. On the other side of the scales a particular feature of the steam turbine—the change of state of the working fluid—which provides a high specific output, proves to be its main handicap towards better efficiencies.

In Fig. (1) a comparison is made of the ideal gas turbine cycle (without heat exchanger) with an ideal Rankine cycle—both cycles operating within the same temperature limits.

The mean temperature levels

$$\overline{T} = \frac{\int dQ}{\int \frac{dQ}{T}}$$

of both heat intake and heat release are higher for the gas turbine than for the steam turbine but since the ratio of these two decisive temperatures are of the same order in both cycles, the two efficiencies are likewise of a similar order.

If the Carnot efficiency corresponding to the assumed temperature limits is to be approached the mean temperature of heat intake and release must be raised and lowered, respectively, as close to the temperature limits as possible. It must be remembered, however, that it is not necessary to imitate the rectangular shape of the Carnot T.S. diagram. The Joule isobar-isotherm process carried out by an ideal gas has the same efficiency if a perfect heat exchanger is used. What really matters is that the breadth of the strip in the T.S. diagram should be as constant as possible, while any irreversible losses occurring within the area between heat intake and heat release should be as small as possible. The chief means of achieving this is by heat regeneration, whereby heat is transferred from the right-hand side of the diagram to the lower parts of the left-hand side. The effect of this is shown in Fig. (2), whereby a gas turbine with heat exchanger (a) is compared with a steam turbine incorporating three stages of bled steam feed heating (b). In both cases regeneration means a reduction of specific output—this reduction is small for the steam turbine—it is considerable in the case of the gas turbine. In both cycles a considerable improvement in efficiency is achieved. If attempts are made to lift still further the temperature level of heat intake in the steam cycle difficulties at once arise through the necessary use of high pressures, and when these have been exploited to the economical limit the only remaining possibility of improving the average level of heat intake is by further development of the upper right-hand portion of the diagram by reheating. Reheating may also be conceived as an attempt to replace polytropic by isothermal expansion but owing to plant complications it is in general restricted to one or at most two stages.

In Fig. (3b) is shown a steam cycle with three feed heating stages as in Fig. (2) but with the addition of one stage of reheat (a second stage of reheat and the possibility of introducing a regenerator are also indicated).

Although the mean temperature level of the heat intake through the superheater and the reheater approach the turbine inlet temperature with a consequent improvement to the cycle efficiency the added areas of useful work are insufficient to offset the preponderance of the low heat level intake from the boiler. The effect of superheat and reheat is still further handicapped through the fact that superheated steam does not behave as a perfect gas. As shown in Fig. (1) the isobars sag in the neighbourhood of the saturation line at high pressure and thus diminish the area of useful work which would otherwise accrue from superheating.

The gas turbine for its part can usefully partake of a similar development and the gain is relatively greater because of the closer approach of the working medium to a perfect gas.

In addition the gas turbine can gain at the lower end of the diagram by using intercooling in the compression stage. There are two versions of intercooling and reheating, which the gas turbine can accept. If they are adopted in order to increase the output all that is necessary is to arrange several strips of the original diagram alongside each other. The average temperatures of heat input and release then remain practically the same and so does the efficiency. The other version of reheating and intercooling is that, where for given limits of pressure, the number of stages is increased so that the isothermal line is more nearly approached and the efficiency improved. Since the plant required for one stage of reheat is bigger than that for one stage of intercooling the best solution is obtained by introducing about two expansions as against three or four compressions (Fig. 3a).

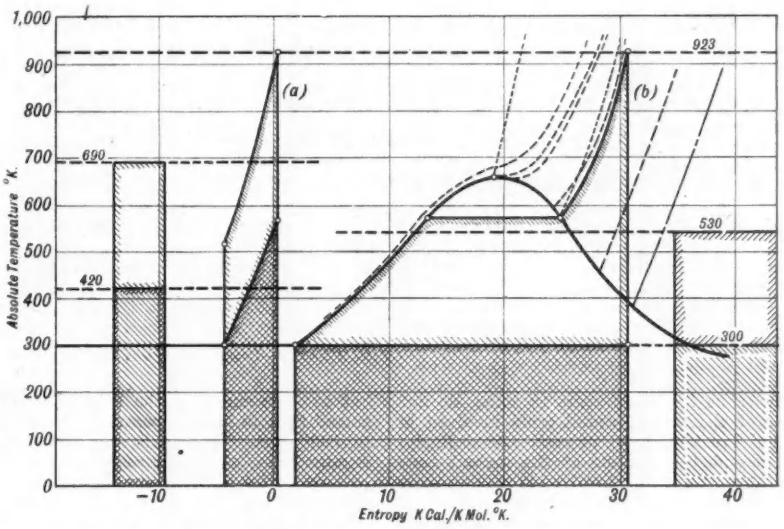

FIG. 1—*Comparison of Ideal Gas Turbine and Rankine Cycles*

By adopting reheat and intercooling, by fully adopting all expedients to keep the irreversible losses low and in particular by the design of a high grade heat-exchanger the gas turbine can be developed to a form where as regards efficiency it is thermodynamically superior to the steam turbine, although its comparatively low specific output will, in spite of all expedients, limit its scope to power units of moderate output.

It is important to distinguish between gas turbine expectations and the gap that may exist between such expectations and their realisation in practice. There is always a considerable margin between the potential and the actual operation of a power unit, since reliability and economy in design, which do not figure in efficiency calculations, are generally by far the most important factors in the operation of any prime mover used in public service.

In the case of the steam turbine and the present forms of internal combustion engine, operational levels have been determined as

* British Association, Birmingham, September, 1950.

the result of long experience under service conditions and it is necessary to guard against comparing such prime movers with the potential and as yet untried operating level of the gas turbine. Those of us who have been fortunate enough to be concerned with the design and manufacture of large units, can speak with first-hand authority on the difficulties associated with their production, particularly those relating to the fabrication of large austenitic steel castings and forgings. We can also speak feelingly of the cost of such items. So, too, can we speak of the difficulty and cost of producing large turbine and compressor blades, either in ferritic or austenitic materials, and of the time factor involved, no matter by what process, in the production of the hundreds of compressor and turbine blades required for gas turbines of large output. In the aircraft industry, it has been possible because of the use of large numbers of blades of the same type to break down the machining process into a large number of steps, enabling the cost of turbine or compressor blades to be reduced to a few shillings, but the numbers of large gas turbines now in course of construction or plant and are therefore lacking in those essentials which make this prime mover so attractive in comparison with other forms. Even so, in spite of these severe drawbacks, I am confident that large oil burning units will find a definite if limited application in circumstances where the running hours are low or where because of the strategic setting of a particular power station in regard to distribution, the potential economy in space could be utilised. Nevertheless, in general, the tendency in large generating stations is to use power units of larger and larger output and there is every indication that power stations in this country will, in future, be equipped with units of 100MW. Gas turbines cannot at present be built in such sizes economically and unless therefore they show a considerable increase in economy both as regards physical size and operation, their use in power stations, whether as coal or oil burning units, is likely to be restricted. Both requirements would, of course, accrue from the use of much higher gas temperatures than those now in general use.

The field for gas turbines of small or medium output is most promising not only in theory but to some extent in the light of experience gained to date in the operation of units of up to 5000 h.p. The small unit embraces the requirements of a successful prime mover because of its inherent simplicity, its modest cost when made in anything like reasonable numbers, its reliability when designed with reasonable conservancy and its useful if somewhat modest efficiency of operation.

It is a platitude, but one which stands repetition, that the successful development of the gas turbine in industry in this country at least depends on the quality of the fuel it can burn.

In their experimental gas turbine at Heaton, Messrs. C. A. Parsons have burned successfully residual fuels of up to 3000 secs. viscosity, but, on the other hand, trouble has sometimes been experienced with much lighter fuels having viscosities of the order of 200 secs. In the main, it may be said that little or no difficulty is experienced or is likely to be experienced in the actual burning of heavy residual fuels, since with adequate preheat the normal swirl type burners with or without air associated atomisation, will prove suitable. The real trouble arises through deposits on the turbine blading and corrosion.

Most residual fuels contain vanadium, sodium and sulphur in varying amounts, depending upon the origin and upon the processes used in refining the lighter fractions from crude. The types of corrosion that are liable to occur during operation are the direct combination between the metals and oxygen and sulphur, and the fluxing of protective oxide films by constituents such as vanadium-pentoxide and sodium-sulphate, which occur in the fuel ash. The reactions between metals and atmospheres containing oxidising gases and sulphur compounds have been studied extensively but much remains to be done and it has to be borne in mind that besides producing general wastage, exposure to oxidising gases and sulphur compounds can result in the removal of constituents from the metals, in intercristalline penetration and in the formation of sub-scale layers unfavourable to endurance under repeated stress so that stress-corrosion and corrosion-fatigue can be important at high temperatures as well as at atmospheric temperature.

Fluxing of protective oxide films by ash deposits occurs mainly through vanadium-pentoxide and sodium-sulphate separately or together. As long as distillate oils or residual oils free from those constituents are used, or as long as the temperature of the components in contact with the products of combustion is not above the melting point of the ash constituents, no fluxing occurs, but when the products of combustion from fuels containing vanadium or sodium come into contact with components maintained at temperatures above some 650 deg. Cent., the tacky ash particles may stick to the component and flux the protective oxide. The rate of this attack increases rapidly with the temperature and different heat-resistant materials show different degrees of resistance to it, but it seems generally true to say that a long life cannot be expected from components that depend on protective oxide films for their resistance to oxidation if they operate above 650 deg. Cent., in contact with the products from fuels containing the ash constituents mentioned. As the heat-resisting properties of metals at high temperatures depend almost entirely on the restriction of oxidation by suitable oxide films, the seriousness of this problem is at once apparent. The formation of the compounds vanadium-pentoxide and sodium-sulphate, which become sticky within the temperature range obtaining in the turbine is not independent of the combustion system used. For the most part these compounds are likely to be contained in the ash of the oil droplets after the combustibles have been burnt off. By controlling the mean oil droplet's size, by introducing the tertiary or cooling air in proper proportions at the appropriate times to provide a certain degree of chilling or by altering the velocity through the combustion chamber and thus controlling the time available to complete the combustion, it appears possible to provide a containing envelope of unburnt carbon within which the sticky vandium and sodium compounds are held so that they do not adhere to the turbine blades. Care is needed, of course, to ensure that the droplet sizes are not so large or the unburnt carbon so great as to make for bad combustion and the possible formation of large unburnt residues which might cause erosion of the turbine blades. There is already a good deal of evidence to show that these conceptions are reasonably valid and without doubt controlled combustion will go a long way to allow of the burning of residual fuels without causing blockage of the blade passages. Whether corrosion of the turbine components by vanadium-pentoxide, sodium-sulphate or

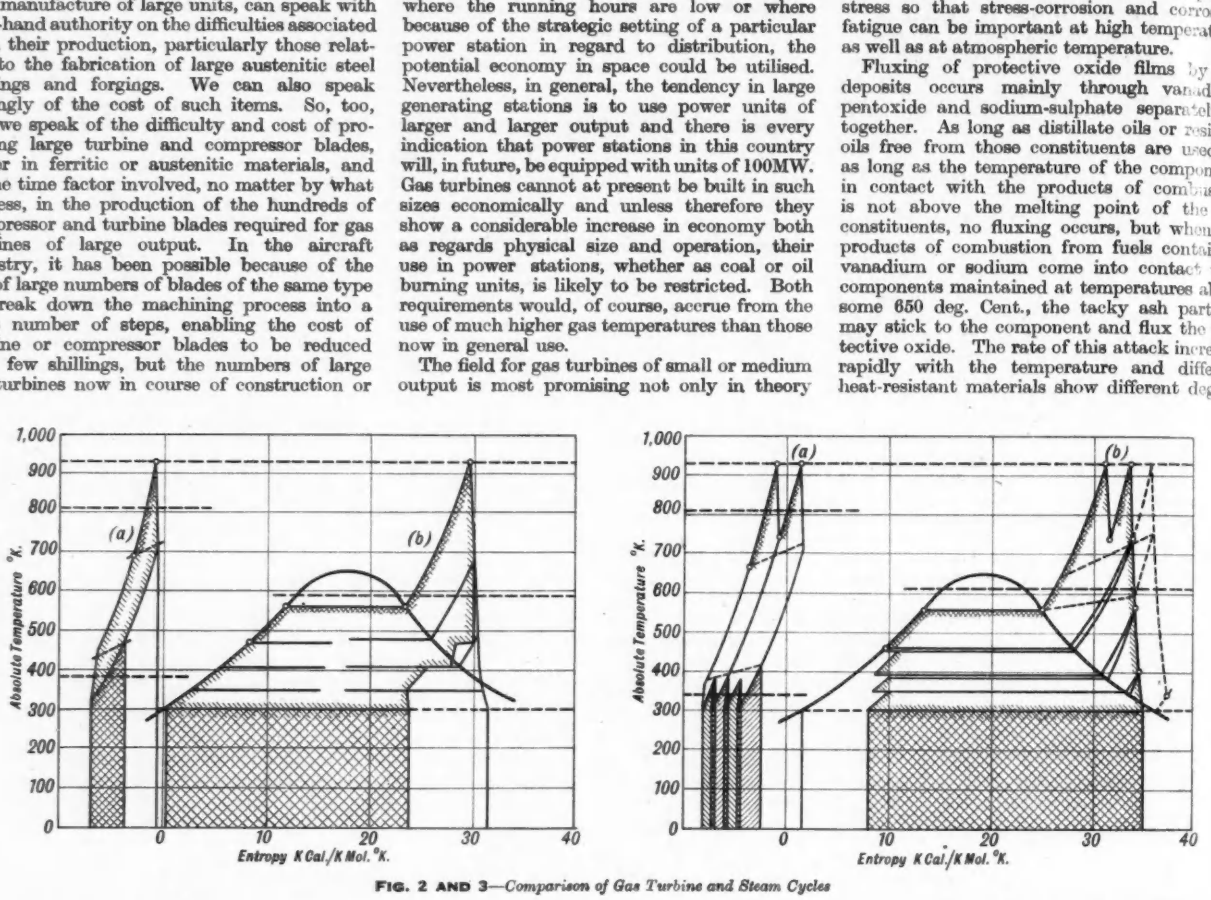

FIG. 2 AND 3—*Comparison of Gas Turbine and Steam Cycles*

likely to be for many years to come, do not allow of the heavy capital costs involved in such a breaking-down process. Accordingly, the manufacturing costs at the present time and the length of time involved in making these blades, are a very serious handicap to the economical exploitation of the large industrial gas turbine. In order that it may compete with steam turbines of similar output, the large gas turbine, from the very outset, is saddled with a complex and costly heat cycle, involving one or more stages of inter-cooling and at least one stage of reheat. These features are necessary in order to reduce the mass-flow to manageable proportions. Apart from the price of the said intercooling and reheat components, they involve considerable lengths of additional piping or duct-work and also introduce complications of control.

The use of heat-resisting steels, which usually possess relatively high coefficients of thermal expansion and relatively low yield points, calls for the utmost ingenuity in avoiding the loads, distortions and stresses due to temperature differentials, which inevitably obtain in the plant. Accepted steam turbine practice is evidently not suited to a machine in which part-load conditions involve considerable temperature changes. To meet such requirements large variations in material section must be avoided if distortions are to be kept within acceptable limits, and while most of the problems involved yield to analysis in the design stage many will only be finally resolved under operating conditions. The stable form which the large gas turbine will assume is likely therefore to be the result of a fairly long drawn-out process of cut and try.

From these few remarks it will be evident that large industrial gas turbines lack the simplicity and potential cheapness of production of the small and medium gas turbine

other compounds, can take place at elevated temperatures in the absence of actual deposition is not yet certain.

Apart from certain success which we have had in this country in burning heavy fuels, encouraging reports have been received from America of the operation of a gas turbine-driven locomotive operating on 3000 secs. oil fuel. These results are encouraging but there is not likely to be a large margin between success and failure in the burning of some types of heavy fuel and it is therefore essential at this stage to strike a note of caution. Only long-term results obtained from operation under service conditions will provide the true answer.

The efforts which have been made in America towards burning coal in a gas turbine-driven locomotive are well known, and some success has attended the intensive work which has been undertaken during the last four years.

Largely at the instigation of the Ministry of Fuel and Power, work is now being undertaken in this country on methods of burning coal in gas turbines. The extent of this has been dealt with in a paper read by the chief scientist of the Ministry of Fuel and Power to the Institute of Metals,† from which it may be noted that in addition to the possibilities of coal burning, the Ministry is alive to the benefits to be obtained by the successful exploitation of our extensive peat deposits.

Apart from the problems concerned with the actual burning of coal or peat, the outstanding problem is that of disposal of the large amount of ash. Its collection and disposal are likely to be costly but from the information available it would appear that it is technically possible by means of a two-stage cleaning system of the type used by Yellott in his American locomotive application. It is still not quite clear to what extent it is necessary to remove dust particles below 20 microns in order to prevent erosion of the turbine blading. It does seem, however, that it is necessary to extract most of the dust occurring above this figure. Although supersonic and other methods may have some application, it is likely that small cyclone type extractors will prove the most practicable system for taking out the fine dust.

Slagging vortex-type combustion chambers are now being increasingly used in America in steam power stations and a number of such burners will shortly be appearing in this country. In this type of combustion chamber final combustion is obtained by throwing the coal on to the hot refractory lined walls from which some 90 per cent of the ash can be removed as liquid slag. This very considerably relieves the burden to be borne by the mechanical cleaning system adopted, although the volume to be dealt with, and therefore the size of the cleaners, is not likely to be substantially reduced if the whole of the air passes through the slagging vortex combustion chamber.

At first sight it may seem a little indelicate that we should consider at all passing the products of combustion from residual oil fuels or high ash coal, through the delicate, carefully designed channels of a gas turbine. As distinct from the axial-flow compressor, however, the turbine is an accelerating-flow machine and experience has shown that it will withstand some considerable abuse before its operating efficiency is very materially affected.

The successful solution to the burning of coal in gas turbines will open up a large new field for their use. More so will this be the case if they can be made to burn low-grade coal, of which there are large supplies at coal pits throughout the country and which at present is to all intents and purposes a waste product. Small gas turbines of up to, say, 2500kW, burning slurry, would find a welcome in our collieries where they would be used both for power, lighting and process steam requirements.

The gas turbine is never happier than when it is burning gas. This may take the form of town gas, oilfields gas, blast furnace gas, or coke oven gas, and it is as a gas burning machine that some of its most potentially useful applications lie. Not so very long ago blast furnace gas was often a waste product in our iron and steel works. This is seldom so at the present time, when its heating value is as precious as that of the coal from which it was made. Again, in the oilfields the day of the wastage of millions of cubic feet of high calorific value gas is slowly passing and so, as in most other applications, the gas turbine using this type of fuel will have to stand on its own feet in comparison with other types of prime mover. It is, however, particularly adapted to steel works, both for power and blowing purposes, since there is here no competition as between coal and oil as the operating fuel and the chief considerations are therefore initial cost, reliability and operating efficiency. There is little doubt but that when conditions in the steel industry become stabilised, early efforts will be directed towards the installation of suitable gas turbine plant operating on blast furnace gas, coke oven gas or a mixture of the two. Already, in the U.S.A., a few gas turbines ranging in output from 2000/5500 h.p. have been built and are now operating in oilfields on oilfields gas, either for pumping or electrical power generation. Oilfields applications such as these form one of the most attractive outlets for the small or medium-sized turbine.

† May Lecture, 1950, Dr. Roxbee Cox.

Locomotives

The application of the gas turbine to the locomotive has received considerable attention in this country, Switzerland and America, and a number of units are already in operation. At first sight the locomotive field appears to be a promising one for the gas turbine. The present steam locomotives are notoriously inefficient and, depending on the cycle conditions, the gas turbine may be expected to have a full-load efficiency at the wheels of from 18 to 21 per cent.

In comparison with the steam locomotive, the efficiency of the gas turbine suffers under part-load operation. Although under full load conditions the efficiency of a gas turbine locomotive may be 20 per cent, at 25 per cent load it is just as likely to be 12 per cent, and perhaps under certain circumstances even less. This may be compared with the efficiency of a steam locomotive of some 5 or 6 per cent. Over a long run, therefore, it may well be that the efficiency of the gas turbine-driven locomotive is less than twice that of the steam engine and, having regard to the prevailing costs of boiler fuel oil and coal, the running cost would be less for the steam than the oil-fired gas turbine locomotive. The initial cost of the latter will be much higher than that of the former and so selection of the gas turbine locomotive using oil as fuel can only be made on the grounds of increased reliability or greater availability. With all its faults, the steam locomotive is a very reliable machine and it is unlikely that the gas turbine will show to advantage in this respect. Its availability is likely to be much better than that of the steam-driven locomotive, but the opportunities for making use of this increased availability on British Railways is very limited because of relatively short hauls and the time schedules which have to be maintained.

Train heating, braking and other ancillary requirements, all of which are simply and effectively carried out on the steam locomotive, require special apparatus and controls on the gas turbine-driven unit.

Having regard to the traffic density in this country we have a relatively large number of locomotives compared with, say, the U.S.A., and large-scale replacement of existing steam locomotives with the more expensive oil-burning gas turbine locomotive would almost certainly prove an insuperable financial burden. As in the U.S.A., it is most desirable that every attention should be given in this country to the possibilities of using coal-fired gas turbines for locomotives. If this can be done successfully and if, in addition, mechanical instead of the more expensive electrical transmission were introduced, there would be a better case for the gas turbine locomotive on British Railways than now obtains with the oil-fired electrical transmission type. It must not be assumed that the remarks in regard to economy, which have been made above, are peculiar to the gas turbine. They apply in large measure to diesel, electric or other initially expensive types.

While much effort has been directed towards production of gas turbines of large output and a great deal more is now being directed to the manufacture of medium-sized plants, there is a growing consciousness of the possibilities of the gas turbine for quite small outputs of between, say, 50–350 h.p. There is, furthermore, a growing pressure upon manufacturers to consider the implications involved in the design and manufacture of such units. In aerodynamic machines the Reynolds number usually puts a limit to the size where an acceptable operating efficiency can be obtained, and generally speaking, aerodynamic machines of the order of 50 h.p. would not show an efficiency in any way comparable with that obtainable from the internal combustion engine of similar power.

There are, however, quite a number of applications where, because of the small load factor, a poor efficiency is acceptable because of counter attractions such as lightness and small first-cost. Portable pumping engines come to mind immediately in this regard and I do not doubt but that gas turbines of the sizes I have indicated will some day be used for these and similar purposes.

The prospective developments of the gas turbine are likely to be concerned with the utilisation of higher gas temperatures and higher heat exchanger efficiencies. The run of mine gas turbine of the future will almost certainly employ cooling. Cooling may be looked upon as an inherent part of its basic design, just as it is for the internal combustion engine. The final form of the cooling system will only come to light in the hard school of experience. Air cooling of combustion chamber liners and turbine discs is now almost universal in small or medium output machines. Blade-root cooling is adopted in many instances but apart from its use in Germany during the war, cooling of the turbine blades has only been attempted experimentally. The high relative velocities obtainable between the turbine rotor and the surrounding cooling air allows of a very efficient interchange of heat and a handsome dividend for the use of quite a modest quantity of the precious high pressure air. For operating temperatures of up to 700 deg. Cent or more, air cooling of the rotor allows the use of some of the better quality ferritic materials for long life operation, thus effecting a considerable saving in cost and fabrication.

Provided it can be maintained by successive incremental renewals, a cool air film spread over the bladed rotor surface will do much to prevent heat inflow into the rotor body. The efficiency of such a system is well illustrated in the practice now almost universally adopted of cooling the combustion chamber flame tube by "stepped," "flowerpot," or other type of interrupted surface design.

There are many advocates of liquid cooling for both the turbine rotor and turbine blades. Many ingenious systems have been devised and some have even been tried out on a small scale. Whatever the merits of liquid cooling on paper, the gain will need to be very substantial to offset the complications which must arise in its application.

Gas turbines may be made efficient without a heat exchanger by a proper selection of the compression ratio for the given operating gas temperature, but the inclusion of a heat exchanger allows of a very much lower pressure level for a given temperature level and gives better efficiency of operation under part-load conditions. It takes the load from the compressor side of the cycle with, in most cases, beneficial results. In other words, if we can regard the gas turbine as a high temperature-level exhausting machine, its construction is simplified. From the very fact that a turbine has a large swallowing capacity in a relatively small space as compared with a reciprocating internal combustion engine, it is possible usefully and economically to avail ourselves of the heat in the exhaust to heat up the air for combustion. Large volumes of the hot inlet air can be easily dealt with by the turbine, that would be prohibitive in petrol or diesel engines.

To date, the method of utilising this exhaust heat has been the use of counter-flow, cross-flow tubular or extended surface heat exchangers, but their cost becomes almost prohibitive when thermal ratios greatly exceeding 75 per cent are contemplated. Such heat exchangers, even with small tubes, are heavy, bulky and expensive and certainly for small plants of up to 5000kW capacity, the cost forms far too large a proportion of the total cost of the plant. It is not surprising therefore, that throughout the world considerable attention has been and is being given to the construction of a highly effective type of heat exchanger of low cost, generally described as regenerative, typified by the Cowper Hot Stove of the steel works. For large outputs the switching system as used on the Cowper Hot Stove becomes costly and clumsy and so a great deal of consideration has been given to the continuously rotating type, wherein a rotating matrix of ceramic or other suitable material receives heat from the hot gases and gives it up in part to the relatively cold air.

A lot of work on the mathematical side of this problem has been done in this country, chiefly with a view to determining the optimum matrix hydraulic diameter for a given duty, but not nearly enough work has been undertaken on the mechanical problems involved of sealing one high pressure fluid from the other. The leakage from a heat exchanger of the regenerative type takes place after the work has been put into the compressed air at the overall efficiency of the plant and so a 1 per cent loss is equivalent probably to 3 per cent in the overall performance. To show an acceptable improvement over the more rugged, straightforward recuperative type, one must aim for a thermal ratio of the order of 90 per cent. A leakage loss of some 5 per cent would bring this down to approximately the same level as is economically obtainable by the recuperative type.

It is not easy with a pressure difference of four or more atmospheres to confine the leakage to acceptable figures, but the prize is so great, the whole field of gas turbine operation would be so largely extended and the cost so considerably reduced, that a much greater effort than has so far been devoted to the subject is justified.

As to the form future designs will assume, it is already apparent that the urge is towards that simplification of physical lay-out which the inherent characteristics of the gas turbine allows. The so-called split turbine arrangement seems set for outputs of up to 5000 h.p. It provides a compact lay-out with low pressure loss and allows of that degree of streamlining demanded by modern power plant users. The components are readily handled and the separate compressor and work turbines make for good part-load operation.

Gas turbines of small output, say, from 50 h.p. up to 350 h.p., are likely to be designed as radial flow units.

In the necessarily limited compass of the paper it has only been possible to touch on the fringe of some of the design and economic factors which are influencing and are likely to influence, gas turbine developments. The thermodynamic cycle is fundamentally sound; it admits of the design of simple units of small or medium output. Production in reasonable numbers will result in a relatively cheap and reliable machine and without doubt a useful field for this "cinderella" of prime movers. Its scope will be limited by the relatively small specific output and by the fuel it can reliably burn in service.

SCHOFIELD TRAVEL SCHOLARSHIPS.—The Institution of Production Engineers announces that applications are now invited for the 1951 Schofield Travel Scholarships. These scholarships were awarded for the first time in 1950, when the two successful graduates were selected for six months' study visits to industrial concerns in the United States of America. It is intended to offer two scholarships for 1951, which will entitle one graduate to visit the United States of America and the other to visit Switzerland.

Continental Engineering News

Development of the Building Material Ytong in Sweden

YTONG is a Swedish building material made from the shale lime. Shale lime was used first for the construction of quay walls and locks of the Göta Canal, linking Gothenburg, on the Swedish West Coast, to Stockholm, in the early decades of the nineteenth century. During the World War I experiments were made on so-called cellular stone, for which bituminous shale was used. Ytong was first made from a mixture of cement and shale lime, and its hardening was achieved by a curing process, as usual for cement products. This air-hardened light concrete showed a tendency to shrink. Shrinkage was, however, overcome by a new method (patented by a Swedish architect, Dr. Eriksson), in which cellular stone was produced from shale lime alone, hardened by steam and pressure. The steam hardening solved a very important technical and economic problem and the shale lime found new and far-reaching uses. At present, Ytong is manufactured by the Yxhult Stone Quarrying Company, Central Sweden. The process of manufacture may be briefly summarised as follows:—The shale ash and burnt lime are crushed and milled and are then mixed with water and a fermentive agent to form a shale lime slurry, which is then run into iron moulds, giving a cellular mass. This mass is cut into blocks or slabs of the required shape and size and then put into autoclaves for steam hardening. Ytong is said to have a uniform cellular structure and consequently a high insulating capacity. At present the capacity of Swedish plants producing Ytong amounts to some 10 million cubic feet per annum.

Development of Belgian Highways in 1950

Because of the large and continuing increase in the numbers of cars and lorries (about 400,000 in 1950 against 240,000 in 1939) the Belgian Highway Board (Ponts et Chaussées) has prepared an important programme of road modernisation. This programme, extended over a period of five years, is summarised in the following table:—

	Years					
	50	51	52	53	54	Total
miles... ...	260	210	158	200	160	988
Mill. B.Fr.	2000	1750	1500	1250	1000	7500
Mill. £ ...	14·3	12·4	10·8	8·9	7·2	53·6

The main improvements will concern the roadway, which will be widened from 20ft to 30ft (three lanes of 10ft each). It is estimated, however, that this measure will not be the final solution of the problem. To meet future traffic requirements the Highway Board is building a system of motorways, which will be dual two-lane highways, 24½ft wide each, reserved exclusively to motor traffic and eliminating any level crossings of railways and highways. The construction of these motorways is now well advanced.

A New Bridge Over the River Po, Italy

Near Santa Maria the River Po is divided into two branches, the Po Grande and the Po di Goro. Some fifty years ago a bridge, about 1080ft long, was erected over the River Po Grande, near Curicchi. The structure, composed of five steel lattice truss spans, was destroyed during the war by Allied bombardment. Owing to the importance of this bridge the Italian Ministry of Public Works decided to restore the structure soon after the end of the hostilities. The contract was let to the firm "Officine Bossi," of Milan. The new bridge is a continuous structure, composed of five spans—184ft, 224ft, 224ft, 224ft and 184ft long respectively—divided into nine and eleven panels. The main girders, 14½ft deep, are of the vee lattice truss type. They are provided with a lower wind bracing. The decking, 22ft wide between the girders, consists of a reinforced concrete slab carried on five longitudinal girders. There are also two cantilever footpaths, 3·3ft wide each. About 700 tons of steel were used on the contract, including 60 tons for the reinforcement of the slab. All members of the steel superstructure were riveted. The bridge was opened to traffic in May, 1950.

Port Exhibition "Rotterdam Ahoy," Holland

During the war the port of Rotterdam sustained considerable damage and lost a great deal of its installations and equipment. Reconstruction work pushed on with great vigour led to very favourable results. To celebrate the reconstruction of its port an exhibition "Rotterdam Ahoy" was held between June 15 and August 31, 1950. The exhibition covered an area of some 90 acres in the immediate vicinity of the River Maas. One of the largest exhibits was a basin, measuring 433ft by 83ft, accommodating 325 models of ships having their home base in Rotterdam. There was also a reduced scale copy of the 32,000-ton dock "Prins Bernhard," with a model of the "Willem Ruys" flagship of the Royal Rotterdam Lloyd. Four ships' frames from earlier periods illustrated the development of shipbuilding from all-wooden vessels to the welded ships of the present time. There was also a model in working order of the Rotterdam grain warehouse, one of the largest in Europe, with its capacity of 69,000 tons.

The Lanaye Bridge Over the Albert Canal, Belgium

The Albert Canal, linking the industrial area of Liége with the port of Antwerp, was crossed before the war by sixty-six bridges, which were spread all over its length of 80 miles. Among the bridges, fifty-four were steel structures (generally assembled by welding) and twelve reinforced concrete bridges. All bridges, as well as all locks, were destroyed during the hostilities. Reconstruction of the Lanaye bridge was completed recently. This bridge is a steel structure with a central span 223ft long and two approach plate girder spans 23½ft long each. The central span consists of two Vierendeel girders interconnected by transverse beams and wind bracing, partly assembled by electric arc welding. Owing to the use of welding it was possible to reduce considerably the overall weight of the bridge. About 366 tons of steel were placed on the contract, which was carried out by the Compagnie Centrale de Construction, of Haine-Saint-Pierre.

British Standards Institution

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria Street, London, S.W.1.

BOILER AND SUPERHEATER TUBES

The British Standards Institution has recently published the following specifications:—

No. 494 : 1950. Cold drawn seamless mild steel boiler and superheater tubes for design steam temperatures not exceeding 850 deg. Fah. (454 deg. Cent.). Tensile limits 20 to 28 tons per square inch.

No. 512 : 1950. Hot finished seamless mild steel boiler and superheater tubes for design steam temperatures not exceeding 850 deg. Fah. (454 deg. Cent.). Tensile limits 20 to 28 tons per square inch.

No. 1652 : 1950. Seamless half-per-cent molybdenum steel boiler and superheater tubes for design steam temperatures not exceeding 1000 deg. Fah. (510 deg. Cent.). Tensile limits 25 to 33 tons per square inch.

No. 1653 : 1950. Seamless chromium-molybdenum steel boiler and superheater tubes for design steam temperatures not exceeding 1000 deg. Fah. (538 deg. Cent.). Tensile limits 25 to 33 tons per square inch.

No. 1654 : 1950. Electrically welded mild steel boiler and superheater tubes for design steam temperatures not exceeding 850 deg. Fah. (454 deg. Cent.). Tensile limits 20 to 28 tons per square inch.

These Standards form a part of a series dealing with boiler and superheater tubes. The design steam temperatures applicable to each of the classes of boiler and superheater tubes are given above. The processes of manufacture of the material from which the tubes shall be made are specified and the tensile limits are given with elongations varying with thickness of tubes and form of test pieces. Flattening, expanding and hydraulic tests are also stipulated, together with permissible variations of thickness and diameter. Price 2s. each, post free.

Industrial and Labour Notes

British Overseas Trade

The final figures of the United Kingdom's export and import trade in August have now been published and confirm the estimate made by the Board of Trade last week that the value of exports in that month reached a record figure of £189,500,000, a total 10 per cent above the average for the first seven months of this year. The Board of Trade agrees that shipments of various materials for stock-piling accounted for part of the increase, but says also that ordinary commercial exports were higher than in preceding months.

Exports of manufactured goods in August, at £167,300,000, were 12 per cent above the average for the first seven months of the year, metal goods and textiles making a notable contribution. Exports of non-ferrous metals and manufactures were at a high rate and reached a value of £9,200,000, compared with a monthly average of £5,400,000 during the first half of the year. Bigger exports of copper —sent mainly to Belgium and China—accounted for much of the August increase in this group and the value of tin exported during the month was 19 per cent above the July figure.

Vehicle exports in August were valued at £34,800,000 and were above the average for the earlier months of the year. The August figure included a record number of agricultural tractors, 9884 in all, of which 3196 were sent to Australia and 1730 to South Africa. Another outstanding feature in the vehicle group was pedal cycles, 195,000 of which were sent overseas, principally to British West Africa, India, and Brazil. Exports of cars and chassis in August numbered 34,029, and were valued at £10,000,000. The value of the machinery which was exported in August was £27,100,000. It included a higher proportion than usual of electrical machinery.

Engineering Wages

Discussions between representatives of the Engineering and Allied Employers' National Federation and the Confederation of Shipbuilding and Engineering Unions took place on Wednesday of last week on the subject of engineering wages. It is understood that the employers' proposals on the unions' claim for an increase for adult workers were put forward but no details have been issued as to the nature of those proposals. A joint statement made after last week's meeting said that there had been considerable discussion and interchange of views and that the conference had been adjourned to give both sides an opportunity of consulting their respective organisations.

It will be recalled that at the annual conference of the Confederation of Shipbuilding and Engineering Unions last month, it was stated that the Employers' Federation had suggested, as a basis for negotiation, improvements in rates, which would benefit the lower paid workers. This suggestion followed from informal talks arranged by the Minister of Labour, after he had been officially notified that a state of dispute existed over the rejection of the union claim for a general increase of £1 a week.

The Nationalisation of Industry

Speaking at the annual general meeting of Richardsons, Westgarth and Co., Ltd., last week, the chairman, Mr. O. J. Philipson, said that industries in this country had been plunged into nationalisation against the experiences of such ventures in other countries and against the advice of practical leaders of industry. It was not, he thought, very difficult to foresee that such schemes would prove expensive, as indeed they had. His strong belief was that nationalisation was against the interests not only of shareholders but also of employees, who might find it extremely inconvenient and distasteful if a whole industry was controlled by one single employer.

In industries already nationalised, Mr. Philipson continued, there had been no visible sign of increases in efficiency and consequent reduced prices for improved products or service, which were some of the more obvious advantages so often and so confidently claimed by the nationalisers. On the contrary, results to date would seem sufficient to show that old-established industries, rather than being handed over to be operated by Government appointees, whose qualifications were not always clear, were best left in the hands of men who, themselves, had been intimately connected with them. Those men, Mr. Philipson emphasised, had built up industry and had carried it through periods of depression in trade so serious that it was to be hoped the like would never occur again.

Works Information

The Federation of British Industries has just issued a booklet entitled "Works Information," which has been prepared by its Home Publicity Committee. In its production, the committee has stressed the importance of keeping staff and workpeople as fully informed as possible about industrial developments and achievements and the booklet is intended to convey a few suggestions on methods of preparing and disseminating works information. The suggestions made include notice boards, wall newspapers, easel technique, production charts, posters, works journals, films, exhibitions, works visits, and meetings for discussions. It is acknowledged that firms already familiar with works information schemes will be aware of most of the points made in the booklet, but firms which may be making their first approaches to these schemes will undoubtedly find the material helpful and interesting.

The introduction to the booklet points out that works information need not involve much spending. A large undertaking can afford elaborate equipment but, the F.B.I. asserts, the success of works information does not depend on costly equipment. Indeed, where home-made equipment will serve, it may often prove to be the best!

European Coal Production

The Coal Committee of the United Nations Economic Commission for Europe has recently been in session and has this week issued a report on coal production trends in six European countries. The countries surveyed are the United Kingdom, Belgium, France (including Sarre), Italy, The Netherlands, and Western Germany. In the first seven months of this year, the report says, hard coal production in these countries totalled 253,000,000 tons, which was an increase of 3·2 per cent on production in the corresponding period of last year. But the committee found that solid fuel imports by fifteen European countries during the first seven months of this year were 16 per cent below those in the comparable period of 1949. The decrease is attributed to the falling off of solid fuel imports by France and, to a lesser degree, Italy. Non-coal-producing countries, the report says, have, generally, slightly increased their imports. Another point mentioned in this section of the report is that the virtual elimination of American coal imports in the European market seems to have consolidated itself mainly to the advantage of British and German exports and there are signs, also, of a healthier position in the Belgian export market.

The committee studied employment figures in the coal-mining industry of Europe during July and noted "the continued downward trend in the numbers of men employed in British mines." It adds the comment, however, that Britain increased her coal output during the first seven months of this year, compared with the corresponding period of 1949, thereby indicating a steady rise in productivity. Improvements in productivity, the committee claims, have similarly been achieved in all other major European coal-producing countries. The report goes on to say that the countries represented on the committee agreed upon their future objectives concerning the European coal industry. The delegates present noted the extent of the recovery of solid fuel production in Europe, which, they said, had led to the virtual restoration of European self-sufficiency in solid fuels. Nevertheless, they declared that an increase in coal trade and consumption on a sound economic and technical basis would contribute to a balanced and expanding European economy. Such an increase, the committee concluded, could best be achieved by the promotion of sound competitive conditions in the European coal market, the maintenance of a reasonable degree of equilibrium between supply and demand for solid fuels; the development of conditions conducive to the regular and economic operation of the European coal industry and the assurance that adequate supplies would be freely available to all consumers on an equitable basis.

The committee therefore decided to undertake a detailed study of factors affecting the cost of coal to the consumer in both exporting and importing countries and to study production and consumption trends in solid fuels, including the influence on those trends of developments in the utilisation of other sources of energy. It was also agreed to encourage the increased exchange between member countries of technical information relating to the production and utilisation of solid fuels, and to proceed with such further investigation as might be suggested by this exchange of information.

The I.L.O. and Unemployment

The Ministry of Labour has issued a report on some of the matters discussed at the thirty-third conference of the International Labour Office, which was held recently in Geneva. Among the resolutions adopted at the conference was one relating to action against unemployment, which was submitted by Mr. Alfred Roberts, a United Kingdom workpeople's delegate.

The resolution directed the attention of the United Nations and governments' and workpeople's organisations to certain lines of action, which, it was suggested, should be pursued for the purpose of eliminating unemployment and its attendant evils. These "lines of action" included the suggestion that all governments should ensure that their economic information services and their administrative machinery were adequate and sufficiently flexible to enable them to develop and implement effective full employment policies. It was also urged that governments should give particular attention to the question of how to facilitate economic and social relationships among employers, workers and other groups in the economy, so as to achieve continuing full employment and at the same time to maintain flexibility and efficiency in production and avoid inflation. The resolution then went on to say that measures should be taken by governments to ensure that workers could secure the jobs to which they were best suited, through the development of employment services, and that attention should be given to such matters as mobility of labour and training.

Another clause in the resolution said that in countries where the problems of unemployment and living standards arose through a shortage of capital or of capital equipment, governments should pay particular attention to the promotion of industrial development by action designed to encourage new undertakings, and to increase the supply of capital equipment and of industrial and managerial skills. A further suggested line of action was the promotion of the establishment and location of particular industries and of facilities for power, transport and credit, in such a way as to fit in with prospective developments in the geographical distribution of available labour.

French Engineering News

(From our French Correspondent)

An important report on activity during 1949 has been published by Electricité et Gaz d'Algérie. It shows that electricity production, which was 494,800,000kWh in 1949, increased by 15·1 per cent, compared with 1948 and sales increased by 16·6 per cent. The equipment programme in 1949 cost 12,673,000,000 francs and in that year the Michelet hydro-electric plant, the Boghni-Aval hydro-electric plant and the Oran-St. Hubert Gas plant came into service. In 1951 the Oued Agrioun hydro-electric plant (annual production 185,000,000kWh) and the new thermal plants at Bone and Oran (two 25MVA sets each) will be completed.

* * *

The French re-armament programme is not expected to upset the production of certain products of the motor industry. It is pointed out that it would be too difficult to adapt presses and machinery used in the building of, for instance, touring coaches, for the construction of heavy armoured vehicles.

Production and sale of coaches is expanding and stood at 25,247 in June, 1950, against a monthly average of 15,640 in 1949. On the other hand, the production of heavy lorries and trucks has been declining. The average in 1948 was 7778, but has fallen this year to just over 5000. It is said that markets for these vehicles are saturated, at least in France, and exports both abroad and to the French Union are not sufficiently important to keep production at the 1949 level. It seems certain, therefore, that the heavy vehicle industries will very soon turn to the production of heavy armour.

* * *

The French Ministry of Transport has revealed that it has a scheme for the construction of underground roads in Paris. This scheme has been designed to remedy the growth in the number of cars on the French roads, which is estimated to be about 30,000 a year.

The first two roads would run from the Gare de l'Est to the Observatoire, and from the Gare de l'Est to the Place de la Concorde. Owing to the cost, however, it seems unlikely that these roads will be constructed for a long time yet.

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The 1,300,000 dollers allocated to France under the Marshall Plan on August 30th will be spent on rolled steel products.

* * *

The supply of electricity in France has so improved that there appears to be little likelihood of load-shedding this winter. The hydro-electric storage reservoirs are now 86 per cent full as against only 34 per cent at this time last year. Coal stocks stand at 700,000 tons, giving a thirty-five day margin. The Gennevilliers plant has a new alternator which will be ready by the end of the year, and a second set will soon be given its trials. Various hydro-electric plants, such as that at Rouen-Dieppedalle, will soon commence production.

Electricité de France has estimated that consumption will increase by about 1000 million kWh next year. The increase is already noticeable, but there is every reason to believe that the increased demand will be met. This fact is particularly satisfying for industry, which so far has suffered from power cuts during every winter since the war.

* * *

From October 8th the Paris–Marseilles express will gain 1 h 7 min as a result of the electrification of the Paris–Dijon line, which was recently opened. Electric trains on this line can reach a speed of 135km an hour.

* * *

An exhibition of microscopes, showing examples from the first instruments used to the electron microscope, has opened in Paris. It will remain open until November 30th. The first days of the exhibition coincided with an International Congress of Electron Microscope Engineers, at which papers were read on the use of electronic microscopes in metallurgy, chemistry and biology.

Notes and Memoranda

Rail and Road

RAILWAYS IN SIERRA LEONE.—The Colonial Office says that railways in Sierra Leone are adopting the British practice of naming their locomotives. Each engine in the service is shortly to be fitted with a plate displaying the name of one of the chiefdoms through which the line runs. But there is to be one exception. The shunting engine known over the Sierra Leone system as "Nellie" will retain its old name. It was built in 1864 and is still in regular use, having been taken over by the Railways from the harbour contractors in 1914. Engine, carriage and wagon repair systems have been replanned in the Cline Town workshops, and the most up-to-date methods introduced. In the newly started school for apprentice engine drivers a full-sized model of the main valve gear of a locomotive has been built from scrap.

NIGERIAN RAILWAYS.—A major scheme of capital works is now in hand on the Nigerian Railways, which includes the rebuilding of six major stations, extensions and improvements to eight other stations, the regirdering of the bridge over the Mariga River, and large extensions to the main workshops at Ebute Metta, Lagos. These items, together with purchases of the required additional equipment, will cost an estimated £5,500,000. To-day, the Railways operate a total of 1903 route and 2220 track miles, serving a population of some 25,000,000 and an area of 372,674 square miles, an area approximately one-third that of India. At present there are 269 locomotives, 202 passenger coaches and 3532 goods wagons in operation. Further orders have been placed over the past few years for 96 2–8–2 main line locomotives, 16 0–8–0 shunting engines, 70 new boilers for main line locomotives, 1474 freight wagons, and 48 third-class and 7 first-class coaches.

Air and Water

THE SHIPPING FEDERATION.—Founded on September 30, 1890, the Shipping Federation announces that, to celebrate its diamond jubilee, it is holding a dinner in London on November 23rd, when the Prime Minister will be the principal guest.

AERIAL NAVIGATION IN POLAR REGIONS.—The French Air Ministry has recently issued a publication entitled "Le Point Astronomique Simplifié dans les Régions Polaires," by P. Hugon, which describes a simplified method of aerial navigation particulary applicable to polar latitudes. This publication may be obtained from the Service de Documentation et d'Information Technique de l'Aeronautique Magasin C.T.O., 2, Rue de la Porte-d'Issy, Paris (15).

THIRD ANGLO-AMERICAN AERONAUTICAL CONFERENCE.—The third Anglo-American Aeronautical Conference convened jointly by the Royal Aeronautical Society, 4, Hamilton Place, London, W.1 and the Institute of the Aeronautical Sciences (of America) will be held at Brighton during September, 1951. The technical sessions will be held from September 7th to September 11th, and will be followed by a number of visits to aeronautical firms and establishments in this country.

TROOPSHIP "DILWARA."—Built in 1936 by Barclay Curle and Co., Ltd., the "Dilwara," the first specially designed troopship in the fleet of the British India Steam Navigation Company, Ltd., has been reconditioned and refitted at her builders to bring the ship into line with the post-war troopships. Originally designed to carry 201 passengers, 164 Service families and 1154 troops, the "Dilwara" now accommodates 128 first-class passengers, 112 second-class and eighty third-class in cabins and 705 troops in Standee berths. The ship has recently completed her trials and will shortly sail from Southampton for the Far East.

Miscellanea

THE W. E. HIGHFIELD SHIELD.—The executive council of the Association of Supervising Electrical Engineers announces that the examining board for the W. E. Highfield Shield Competition, 1949/50, has awarded the shield and prize of £5 5s. to Mr. J. McCartney, of Leigh-on-Sea, for his paper on "An Introduction to Atomic Physics."

ENGINEERING INDUSTRIES' ASSOCIATION.—The Engineering Industries' Association is to hold a London Regional Display at the Royal Horticultural Society's New Hall, London, S.W.1, on Tuesday and Wednesday, October 17th and 18th. It will be the third of its kind to be organised by the Association within the last two years and will be open each day from 10.30 a.m. to 7.30 p.m.

IRONFOUNDING PRODUCTIVITY CONFERENCE.—The British Cast Iron Research Association is organising a productivity conference which will be held at Ashorne Hill, near Leamington Spa, on Thursday and Friday, October 12th and 13th. It is stated that the conference will be devoted to a discussion of purely technical aspects of productivity in ironfoundries, arising from the recently published report of the grey ironfounding productivity team.

IRON AND STEEL SCRAP.—Under an Order signed by the Minister of Supply, the Control of Iron and Steel (Scrap) Orders, 1943–1950 have been consolidated. The new Order releases scrap alloy steel, including stainless steel scrap, from price control, but not from control of acquisition and disposal. The schedule to the new Order also lists a limited number of price amendments. The new Order—the Iron and Steel Scrap Order, 1950, S.I. 1950, No. 1523—came into force on September 18th.

LIBERALISATION OF TRADE.—In accordance with Britain's obligations under O.E.E.C. (the Organisation for European Economic Co-operation) and following the signature of the European Payments Union Agreement, the Board of Trade announces that from September 26th the various "liberalisation" import concessions have been extended to Western Germany. These concessions permit the import without individual licence of a wide range of goods from most O.E.E.C. and many other soft-currency countries.

B.E.A. BARKING-ILFORD 132kV CONTRACT.—The contract for the supply and installation for the B.E.A. of 132kV cables between Barking and Ilford has been awarded to British Insulated Callender's Cables, Ltd. This contract is one of the largest projected installations of 132kV impregnated pressure type cable. It will involve some 9000 route yards of two 0·60 square inch three-core, 132kV impregnated pressure cables and associated auxiliary cables, and a small quantity of 0·60 square inch three-core, 33kV solid type cable.

INSTITUTION OF PRODUCTION ENGINEERS.—The Institution of Production Engineers announces the formation of a South Essex Sub-Section. The inaugural meeting of the section will take place in the Great Hall at the South-East Essex Technical College, Longbridge Road, Barking, on Wednesday, October 18, 1950, at 7.30 p.m. At this meeting the chairman of council, Mr. Walter C. Puckey, director and general manager of Hoover, Ltd., will be the principal guest speaker, and his subject will be "Public Service Through Productive Efficiency."

THE INSTITUTE OF EXPORT.—The Institute of Export has recently revised its educational syllabus to take into account the changes in economic and commercial conditions since the end of the war. Courses based on the syllabus will be available during the winter at commercial and technical colleges in London and many provincial centres, and for the benefit of students who cannot conveniently attend oral instruction, postal tuition courses are being provided. Details of the Institute's educational arrangements can be obtained from the General Secretary at Holland House, 140, Cromwell Road, London, S.W.7.

BUILDING EXHIBITION FOR CARDIFF.—Five exhibitions in one, organised by the Ministry of Works to show the technical aspects of modern building, are to be held at Morsmith Garage, Frederick Street, Cardiff, during the week October 2nd to 7th inclusive. The five subjects to be demonstrated are: modern site organisation, plumbing, codes of practice, thermal insulation, and steel efficiency. Exhibits are also being staged by the Wales Gas Board and the South Wales Electricity Board. The exhibition is to be opened by the Right Hon. Lord Morrison, Parliamentary Secretary to the Ministry of Works, at 2.30 p.m. on Monday, October 2nd.

JUNIOR INSTITUTION AWARDS.—The council of the Junior Institution of Engineers has made the following awards in respect of papers and lectures delivered during 1949–50:—Institution Premier Award, to J. S. Mayne, of Sheffield, for his paper on "Mechanical Aids in the Operation of Rolling Mills"; Institution Prize, to N. J. Bowyer-Lowe, of London, for his paper on "The Production and Use of Synthetic Gems in Industry"; Vickers Prize, to S. L. Lyons, of London, for his paper on "Plaster of Paris in Engineering"; Tookey Award, to H. F. J. Higgs, of London, for his paper on "Launch Tugs and Workboats"; Past-Secretary Dunn Award, to W. M. Bond, of London, for his lecturette on "The Use of the Miniature Camera in Engineering," and North-Western Section Prize, to R. D. Boyle, of Manchester, for his paper on "Surveying."

British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

GAS PRODUCERS

640,817. September 6, 1948.—IMPROVEMENTS RELATING TO GAS PRODUCERS, Sir Frederick Joseph West, G.B.E., and Ernest West, and West's Gas Improvement Company, Ltd., all of Albion Iron Works, Miles Platting, Manchester, 10.

This invention relates to gas producers of the type known as mechanical producers in which the grate is revolved in order to effect attraction of ash. The object of the present invention is to provide automatic means for controlling the ash level in the producer within narrow limits which increases the efficiency of the producer and enables the dimensions to be reduced for a given throughput. As shown in the drawing, Fig. 1, the producer comprises a revolving grate *A*, a gas offtake *B*

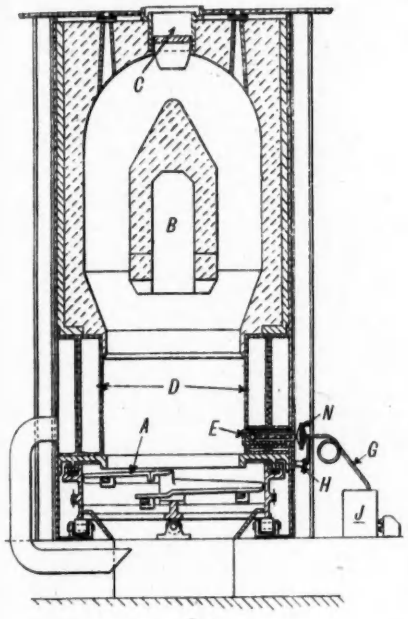

Fig.1

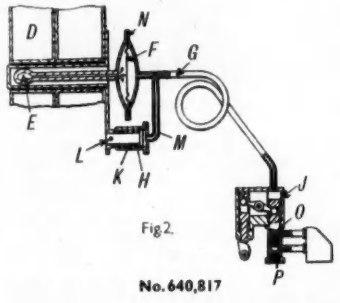

Fig.2.

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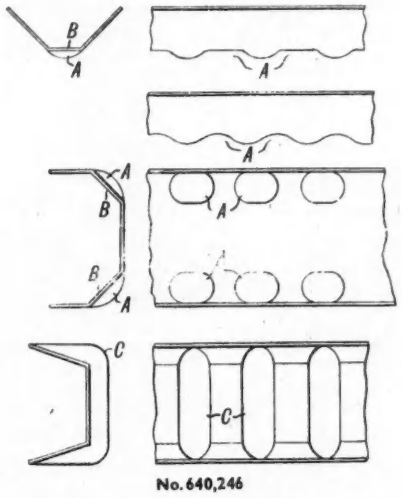
through which the producer gas is delivered across and through one side of the producer, a fuel feed inlet *C* and a water-jacketed combustion zone. In the water-jacketed wall *D* of the producer at about the desired level of the top of the ash bed, is a bulb *E* containing a suitable expansible fluid. This fluid, through suitable means provided, controls the speed of operation of the ash-extracting grate in order to maintain the level of the top of the ash bed where desired. As shown in detail in Fig. 2, the expansible fluid presses upon one side of a diaphragm *F*, the other side of which presses upon a fluid in a pipe *G* and casings *H* and *J*. If the pressure of the fluid in the casing *H* is sufficient to overcome the spring *K*, which bears at one end against the head of the fixed abutment *L*, the casing is moved to the right in Fig. 2, and by means of the rigid pipe *M* carries with it the casing *N* of the diaphragm *F*, and the mercury or like bulb *E*, so that such bulb is drawn back a short distance from the hot zone of the producer and is therefore subjected to a lower temperature. This arrangement prevents damage to the bulb due to exposure to excessive temperature. The fluid pressure in the pipe *G* also tends to depress the plunger *O* in the casing *P* against the pressure of a spring. The position of the plunger determines the speed of the motor which turns the revolving grate, and so the rate of ash extraction from the producer. For example, the grate may be turned by a hydraulic motor, and the rate of reciprocation of the motor be regulated by controlling the rate at which the hydraulic fluid can pass to exhaust, details of such control gear being given.—*July* 26, 1950.

STRUCTURAL ENGINEERING

640,246. December 5, 1946.—IMPROVEMENTS IN STRUCTURAL ELEMENTS OF SHEET METAL, Walter Benno Paul Horrwitz, of 19, Islip Road, Oxford, Oxfordshire (*communicated by Ottakar Georg Ferdinand Paulssen*, of 14, Wodehouse Road, Fort, Bombay, India).

This invention relates to elongated elements of sheet metal, of open angular cross-section, intended for use as beams or struts in engineering structures. The main object is to increase the rigidity of such elements by strengthening the angular parts of their section and thereby to enable them to be used more economically. The invention is described in the accompanying drawings as applied to an angle bar and to a channel bar. The element in each case consists of a single pressed metal sheet. Indentations *A* are uniformly



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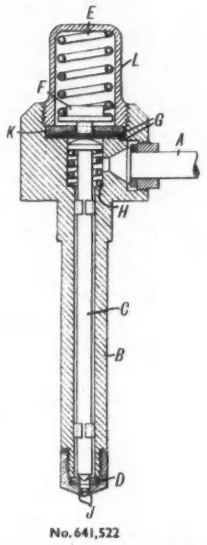
distributed along the bend or bends in such a manner that the section alternates between one in which two straight limbs of the section are joined by a 90 deg. arc of relatively short radius and one in which the two limbs are joined by a straight length *B* lying at an angle of 135 deg. to each limb. The interval between adjacent indentations may be so short that the corner part appears as a continuous corrugation. These constructions stiffen the angle in the same way as would a series of triangular transverse walls fixed across the inside of the bend. The lower views illustrate the use of elongated indentations. In these figures a channel having diverging side walls is provided with elongated transverse indentations *C* pressed outwards and carried across the base of the channel as well as up the side walls. The indentations have the same effect as would a series of separate stiffening members fixed transversely to the element.—*July* 19, 1950.

INTERNAL COMBUSTION ENGINES

641,522. May 19, 1948.—IMPROVEMENTS IN AND RELATING TO FUEL INJECTORS, The Société Anonyme Andre Citroen, of 117, Quai de Javel, Paris, France.

This invention relates to fuel injectors for internal combustion engines, and more particularly to fuel injectors the opening of which is controlled by the elastic deformation of a membrane under the action of the pressure of the liquid fuel to be injected. Referring to the drawing, the liquid fuel is supplied through a pipe *A* and fills the cavity comprised between the body *B* of the fuel injector and the needle *C* and terminating near the bottom of the injector at the seat *D* against which the pointed part of the needle is applied. The cavity is closed towards the top of the injector by a membrane, which, instead of consisting of a single comparatively thick disc, comprises a pile of thin metal discs, each having a thickness of a few hundredths of a millimetre. For instance, instead of a single disc of 0·4mm gauge, the membrane may comprise a pile of five discs of 0·1mm gauge, or better still, twelve discs of 0·05mm gauge. A spring *E* exerts a thrust on an abutment member *F*, which is applied to the needle *C* through the intermediary of the membrane comprising the discs *G*, the elastic deformation of which enables it to transmit this thrust. The thrust of the spring *E* is opposed by the reaction of the seat *D* against which the point of the needle *C* bears. A spring *H* maintains the needle applied against the bottom disc *G* of the membrane. If the fuel is at a pressure which is so low that the force exerted by it on the membrane discs *G* is less than that exerted by the



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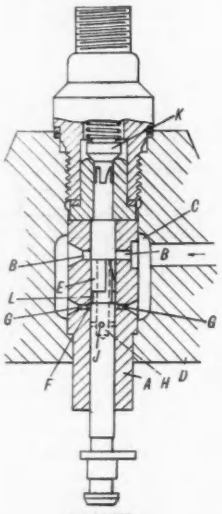
spring *E* the spring will subject the needle to a force directed towards the bottom of the injector. As the fuel continues to pass into the injector, its pressure rises until a moment arrives when the force exerted by the fluid pressure acting on the membrane discs *G* becomes greater than that exerted by the spring, and the membrane discs and the abutment member *F* will be displaced upwardly. The pressure of the fuel tends to apply the needle to its seat and the spring *H* is provided to enable the needle to follow the displacement of the membrane discs. The needle thus rises and, its point no longer forming a fluid-tight joint with the seat, the fuel passes between the seat and the point of the needle and then through the atomising holes *J*, whereby the fuel is injected. When the pressure of the fuel has again become so low that the force exerted by the spring exceeds that exerted by the fluid, the abutment, the membrane discs and the needle are displaced in the opposite direction until the point of the needle is again applied to its seat, whereupon the injection is terminated. The membrane discs *G* are clamped between the body *B* of the injector and an abutment member comprising a washer *K* by means of a screw cap *L*. The shape of the washer *K* is such that it limits the deformation of the membrane discs *G* under the action of the pressure exerted by the liquid fuel, thereby increasing the life of the abutment discs.—*August* 16, 1950.

641,575. January 3, 1948.—IMPROVEMENTS RELATING TO LIQUID FUEL INJECTION PUMPS, C.A.V., Ltd., of Warple Way, Acton, London, W.3 (*Inventor: Fraser Mackie Evans*).

This invention relates to a reciprocatory liquid fuel injection pump for an internal combustion engine of the compression-ignition type, the pump being of the kind adapted to effect each injection of the liquid fuel in two stages. The object is to provide an improved construction enabling the desired effect to be obtained in a simple and convenient manner. Referring to the drawing, the pump barrel *A* (or each of a plurality of barrels) is formed at an appropriate position with a liquid fuel inlet port or ports *B* communicating with a suction chamber *C* in a body part *D* containing the barrel. The port or ports is or are situated adjacent to the position occupied by the inner end of the plunger *E* when at the commencement of its delivery stroke. At any convenient distance from the port *B* there is formed in the barrel a narrow circumferential groove *F*, which extends around at least a part but preferably the whole of the barrel. This groove communicates through ports *G* with any convenient vent which may be the suction chamber or a passage leading to a sump. For effecting the required communication between this groove *F* and the region of the barrel occupied by the liquid fuel to be discharged, any conveniently arranged passage is formed in the plunger. Pre-

ferably an axial or other bore H is formed along a part of the length of the plunger from its inner end, and at or near the closed end of the bore is formed a radial hole or holes J. Starting with the plunger at the commencement of its delivery stroke as shown, the arrangement is such that during the first part of the movement of the plunger the inlet port or ports B are closed by the plunger and a quantity of liquid is then discharged through the outlet valve K at the discharge end of the barrel. But when the radial hole or holes J in



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the plunger come opposite the groove F in the barrel, the discharge is temporarily interrupted and liquid can flow back from the barrel to the vent. Later the radial hole or holes pass away from the groove and the discharge from the barrel through the discharge valve is resumed. In the example above described the barrel is rotatable about its axis in known manner by a governor for regulating the pump output, and the plunger is provided with an appropriate spill passage L for co-operating with the inlet port or ports. The invention may, however, be applied to other forms of reciprocating fuel injection pumps of the kind specified.—*August* 16, 1950.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME and PLACE at which the meeting is to be held should be clearly stated.

Association of British Chemical Manufacturers

To-day to Sun., Oct. **1st.—Chemical Works Safety Conference at Scarborough.**

Association of Supervising Electrical Engineers

Mon., Oct. 2nd.—LEEDS BRANCH: Great Northern Hotel, Wellington Street, Leeds, "Radio Frequency Industrial Heating," L. L. Preston, 7.30 p.m.——N.E. LONDON BRANCH: Angel Hotel, Ilford, "Modern Industrial Electrical Installations," C. J. Veness, 8 p.m.

Tues., Oct. 3rd.—W. LONDON BRANCH: Town Hall, Hammersmith, "Testing and Operation of Modern Electric Metering Equipment," S. W. Stovold, 7.30 p.m.——N.W. LONDON BRANCH: St. Hilda's Hall, Northolt Road, South Harrow, "Cold Cathode Lighting," E. A. Langsdon, 7.45 p.m.

Wed., Oct. 4th.—YORK BRANCH: Royal Station Hotel, York, "Lubricating Oils," B. H. J. Thomas, 8 p.m. ——N. LONDON BRANCH: Three Jolly Butchers Hotel, Wood Green, "The Supervising Engineer and the National Position," A. Brammer, 8.15 p.m.

Illuminating Engineering Society

Mon., Oct. 2nd.—SHEFFIELD CENTRE: The University, Weston Bank, Sheffield, Chairman's Address, J. A. Whittaker, 6 p.m.

Wed., Oct. 4th.—NEWCASTLE CENTRE: Minor Durrant Hall, Oxford Street, Newcastle-on-Tyne, 1, Chairman's Address, J. S. McCulloch, 6.15 p.m.——SWANSEA GROUP: 4, Northampton Gardens, Swansea, "Church and Chapel Lighting," L. C. Rettig, 5.45 p.m.

Thurs., Oct. 5th.—CARDIFF CENTRE: S. Wales Electricity Board, Demonstration Theatre, The Hayes, Cardiff, "Church and Chapel Lighting," L. C. Rettig, 5.45 p.m.——EXETER GROUP: Agricultural House, Queen Street, Exeter, "Modern Methods of Illumination," C. W. Rawlings, 7 p.m.

Fri., Oct. 6th.—BATH AND BRISTOL CENTRE: Provident Hall, Prewett Street, Bristol, "Light, Colour and the Stage," E. E. Faraday, 7 p.m.——BIRMINGHAM CENTRE: Imperial Hotel, Temple Street, Birmingham, Chairman's Address, F. Penson, 6 p.m.——LEEDS CENTRE: Guildford Hotel, The Headrow, Leeds, 1, Chairman's Address, J. W. Howell, 7 p.m.—— HUDDERSFIELD GROUP: Electricity Showrooms, Market Street, Huddersfield, "Fluorescent Lighting in the Hospital," J. K. Frisby, 7.15 p.m.

Incorporated Plant Engineers

To-day, Sept. 29th.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, "Oil Bound Bearings," V. T. Morgan, 7.30 p.m.

Mon., Oct. 2nd.—LONDON BRANCH: Royal Society of Arts, John Adam Street, Adelphi, W.C.2, "The Heat Pump," F. J. Griffiths, 7 p.m.

Tues., Oct. 3rd.—S. WALES BRANCH: Grand Hotel, Westgate Street, Cardiff, "Transmission Problems," H. Power, 7.30 p.m.

Institute of British Foundrymen

Mon., Oct. 2nd.—SHEFFIELD BRANCH: Royal Victoria Hotel, Sheffield, Presidential Address, "Human Relationships in Industry," film, "In Step with the Times," 7.30 p.m.

Institute of Industrial Supervisors

Thurs., Oct. 5th.—WARRINGTON SECTION: Richard Fairclough School, Warrington, Industrial Film Show, 7 p.m.——LEEDS SECTION: Great Northern Hotel, Leeds, "The Foreman and the Factories Act," E. A. Clothier, 7.30 p.m.

Institute of Road Transport Engineers

Mon., Oct. 2nd.—SCOTTISH CENTRE: Institution of Engineers and Shipbuilders, Elmbank Crescent Glasgow, "Recent Developments of the Oil Engine," S. Wightman, 7.30 p.m.

Wed., Oct. 4th.—LONDON: Royal Society of Arts, John Adam Street, Adelphi, W.C.2, Fifth Annual General Meeting, 6.30 p.m.

Institution of Electrical Engineers

Sat., Sept. 30th.—N. MIDLAND STUDENTS' SECTION: 1, Whitehall Road, Leeds, Chairman's Address Mr. Sykes, 2.30 p.m.

Tues., Oct. 3rd.—N. MIDLAND CENTRE: British Electricity Authority, 1, Whitehall Road, Leeds, 1, Chairman's Address, W. F. Smith, 6.30 p.m.

Thurs., Oct. 5th.—Savoy Place, Victoria Embankment, W.C.2, Inaugural Address as President, Sir Archibald J. Gill, 5.30 p.m.

Institution of Engineering Inspection

Tues., Oct. 3rd.—S.W. BRANCH: Grand Hotel, Bristol, "Hydraulics," 7.30 p.m.

Wed., Oct. 4th.—BIRMINGHAM BRANCH: Chamber of Commerce, Birmingham, "T.W.I. of Supervisors," J. G. Harrison, 7.30 p.m.

Thurs., Oct. 5th.—LONDON CENTRE: Royal Society of Arts, John Adam Street, Adelphi, W.C.2, "Production and Inspection of Plain Bearings," H. Roth, 6 p.m.

Institution of Engineers and Shipbuilders in Scotland

Tues., Oct. 3rd.—39, Elmbank Crescent, Glasgow, Presidential Address, "The Car Parking Problem: Requirements of any Adequate Solution," R. Bruce, 6.30 p.m.

Institution of Heating and Ventilating Engineers

Wed., Oct. 4th.—E. MIDLANDS BRANCH: School of Technology, The Newarke, Leicester, "Economics of Automatic Control," T. E. Cunningham, 6.30 p.m.

Institution of Mechanical Engineers

Mon., Oct. 2nd.—N.E. BRANCH: Neville Hall, Westgate Road, Newcastle-upon-Tyne, "Men, Machines and Management," Sir F. Ewart Smith, 6 p.m.

Thurs., Oct. 5th.—N.W. BRANCH: Engineers' Club, Albert Square, Manchester, "The Application of Gas-Turbine Technique to Steam Power," J. F. Field, 6.45 p.m.

Fri., Oct. 6th.—N.E. BRANCH, GRADUATES' SECTION: Northern Gas Board Showrooms, Grainger Street, Newcastle-upon-Tyne, "The Bulk Distribution and Handling of Petroleum Products," P. L. Barnes, 7 p.m.

Institution of Metallurgists

***To-day to Sat., Sept. 30th.*—Science Museum, South Kensington, London, S.W.7, Exhibition, "Metals in the Service of Mankind," weekdays, 10.0 a.m. to 6.0 p.m.; Sundays, 2.30 p.m. to 6.0 p.m.**

Institution of Post Office Electrical Engineers

Tues., Oct. 3rd.—Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2, "The London Station Cable and Wireless Telegraph Section L.T.R.: An Engineering Survey," R. G. Griffiths, 5 p.m.

Institution of Production Engineers

Tues., Oct. 3rd.—READING SUB-SECTION: Great Western Hotel, Reading, "Electronics in Industry," E. J. B. Willey, 7.15 p.m.

Wed., Oct. 4th.—NOTTINGHAM SECTION: Victoria Station Hotel, Milton Street, Nottingham, "What is Wrong with British Industry," Lewis C. Ord, 7 p.m.

Fri., Oct. 6th.—W. WALES SUB-SECTION: Central Library, Alexandra Road, Swansea, "British Clocks and Watch Production," Robert Lenoir, 7.30 p.m.

Institution of Works Managers

Tues., Oct. 3rd.—SHEFFIELD BRANCH: Grand Hotel, Sheffield, Annual General Meeting, "The Psychology of Works Management," W. Higgs, 7.30 p.m.

Thurs., Oct. 5th.—BRISTOL BRANCH: Royal Hotel, Bristol, "Managing a Small Factory," A. H. Huckle, 7.15 p.m.

Fri., Oct. 6th.—NOTTS AND DERBY BRANCH: Mechanics' Institute, Burton Street, Nottingham, "Industrial Management and its Human and Social Implications," A. P. Young, 7.30 p.m.

Junior Institution of Engineers

Fri., Oct. 6th.—39, Victoria Street, S.W.1, Film Evening, "The Manipulation of Corrosion and Heat-Resisting Steels," "Some Applications of Firth Vickers Special Steels," 6.30 p.m.

Liverpool Metallurgical Society

Thurs., Oct. 5th.—Electricity Service Centre, Whitechapel, Liverpool, "Age Hardening," Marie Gayler, 7 p.m.

Manchester Association of Engineers

Fri., Oct. 6th.—Engineers' Club, Albert Square, Manchester, Inaugural Address by the President, J. Adamson, 6.45 p.m.

Newcomen Society

Thurs., Oct. 5th.—One-Day Visit, High Wycombe District.

Society of Engineers

Mon., Oct. 2nd.—Geological Society, Burlington House, Piccadilly, W.1., "High-Frequency Heating in Industry," K. A. Zandstra, 5.30 p.m.

Stephenson Locomotive Society

Sat., Sept. 30th.—N.E. AREA: Visit to N.C.B. Locomotive Sheds, Ashington, 2.30 p.m.——MIDLANDS SECTION: 71, Edmund Street, Birmingham, "Some Locomotives of William Dean," G. H. W. Clifford, 7 p.m.

Stoke-on-Trent Association of Engineers

Wed., Oct. 4th.—Victoria Hall, Hanley, "The Structure of the Universe," Sir Harold Spencer Jones, 7 p.m.

Personal and Business

THE ANGLO-IRANIAN OIL COMPANY, Ltd., states that Mr. Robert Gillespie has been appointed managing director of British Tanker Company, Ltd.

NEWMAN INDUSTRIES, Ltd., Yate, Bristol, states that Mr. Charles Bush has been appointed secretary of the company in succession to Mr. E. B. Piggott, who has resigned for health reasons.

THE RAILWAY EXECUTIVE announces the retirement, on October 31st, of Mr. George Morton, its chief financial officer. Mr. Morton has been in the railway service for nearly fifty years.

THE DUNLOP RUBBER COMPANY, Ltd., states that Mr. A. E. Pickard has been appointed general manager of Semtex, Ltd., the subsidiary company specialising in flooring and decking treatment.

MR. E. S. PAYNE has resigned from the board of Singer Motors, Ltd., owing to ill-health. Mr. H. S. Buswell, who has been in the company's service for twenty-seven years, has been appointed a director.

THE BRITISH COAL UTILISATION RESEARCH ASSOCIATION has appointed Mr. R. L. Brown to be Director of Research Laboratories, in succession to the late Dr. D. H. Bangham. Mr. Brown joined the staff of the Association in 1938.

THE DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH announces the retirement of Mr. Alfred Bailey, A.M.I.C.E., from the staff of the Joint Fire Research Organisation. He has been in the Government scientific service for forty-one years.

MR. A. J. PALMER has been appointed an additional director of Vickers, Ltd. Mr. Palmer is a director of Vickers-Armstrongs, Ltd., general manager of that company's Crayford and Dartford works, and director in charge of the Whitehead torpedo works.

MR. J. W. CARTLIDGE, of Dyson and Co. Enfield (1919), Ltd., has been elected chairman of the council of the Zinc Alloy Die Casters' Association. Mr. E. B. Hill, of Charles Hill and Co., Ltd., and Mr. F. G. Woollard, of Birmingham Aluminium Castings (1903) Company, Ltd., have been elected deputy chairmen.

MR. J. S. RAMSDEN, M.I.E.E., is retiring from the board of the British Thomson-Houston Company, Ltd., after more than forty years in the company's service. He will continue to act as a consultant, and is retaining his seat on the boards of the British Thomson-Houston Export Company, Ltd., Ferguson Pailin, Ltd., and the Switchgear Testing Company, Ltd.

HEAD WRIGHTSON AND CO., Ltd., Thornaby-on-Tees, announces that the name of its subsidiary company engaged in light alloy engineering has been changed from Head Wrightson Aldean, Ltd., to Head Wrightson Aluminium, Ltd. Mr. R. H. Sturges has been appointed director and general manager, and Mr. R. B. W. Bolland, commercial manager.

"THE STORY OF BRITISH ROADS."—In order to cope with inquiries received from teachers and school children for books about roads and road transport, the British Road Federation has recently published an illustrated book with the above title. Several thousand copies are being distributed free to teachers throughout the country, and further copies will thereafter be available, price 6d. each, from the British Road Federation, 4A, Bloomsbury Square, London, W.C.1. The book is intended to serve as a supplement to the film of the same title which the Federation produced earlier this year.